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PROGRESS REPORT ON 1-11
HIGH ALTITUDE PLASTIC BALLOONS
CONTRACT NONR-710(01)
JANUARY 20, 1953 to FEBRUARY 4, 1953
VOLUME VIII
CONFIDENTIAL SECURITY INFORMATION

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PROGRESS REPORT ON RESEARCH AND DEVELOPMENT IN THE FIELD OF HIGH ALTITUDE PLASTIC BALLOONS

CONDUCTED UNDER
CONTRACT NONR-710(01), NR 211 002
FOR PERIOD 20 JANUARY 1953 TO 4 FEBRUARY 1953
WITH THE
OFFICE OF NAVAL RESEARCH

AND SPONSORED JOINTLY
BY THE ARMY, NAVY AND AIR FORCE

Prepared by the
Department of Physics
University of Minnesota
Minneapolis 14, Minnesota

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PROGRESS REPORT ON CONTRACT #710(01)

From 20 January 1953 to 4 February 1953

VOLUME VIII

CONFIDENTIAL SECURITY INFORMATION

Table of Contents

Section I

JOINT OPERATION WITH WINZEN RESEARCH, INC. FOR SKYHOOK FLIGHTS AT PYOTE AIR FORCE BASE

Introduction

The thirteen flights described in this report were made during a joint operation with Winzen Research, Inc. of St. Paul for the dual purpose of carrying cosmic ray scientific gear to high altitudes at a 40° geomagnetic latitude, and to give information of value to the balloon research program in the nature of flight performance of the various balloons, meteorological trajectories, etc. The operation was set up on a cooperative basis with Winzen Research through ONR with the understanding that the balloons, including the packing, would be provided by Winzen Research to the specifications of the University of Minnesota. The University of Minnesota would furnish the control instrumentation for the balloons including pressure telemetering by the Olland Cycle method developed at the University. Down cameras to measure trajectories accurately and the usual CAA safety devices and flight termination devices would also be furnished by the University. Winzen Research would assume responsibility for tracking and recovery along with the University and would participate in the launching in order to become familar with the launching method developed at the University. The cost of the balloon and the necessary packing using the University of Minnesota launching technique would be carried by the project SKYHOOK. Other costs would be assumed by the University of Minnesota High Altitude Balloon Project and the Cosmic Ray Project as required. The operation took place at Pyote Air Force Base, Pyote, Texas, during the period 20 January 1953 to 4 February 1953. The balloons were launched from the apron near the first hangar on the northeast end of the air field very close to the shed in which working space was provided for the scientific apparatus. Helium was obtained from a helium tank car on a siding adjacent to the launching area. The Air Force Base provided

vehicles for the members of the project and housing facilities in the barracks. The excellent cooperation of Lt. Col. Max L. Piper, commanding officer, and various members of the base are acknowledged. Besides the 13 flights reported herein, two other flights were made by Winzen Research using the Minnesota launching technique but using instrumentation provided by Winzen Research. These flights are reported separately in a Winzen report. The University of Minnesota Balloon Project was represented for all or part of the operation by Drs. Edward Ney and John Winckler; Messers. Raymond Maas, Robert Howard, Charles France, Carl Ebneter, pilot, and Donald Hanson. Scientific investigators present included Nahmin Horwitz, Kinsey Anderson, Leland Bohl, John Linsley and Frank McDonald, these from the University of Minnesota. Winzen Research, Inc. was represented by Mr. Otto C. Winzen, Vern Baumgartner, electronics chief; Herbert Ballman, electronic technician; Robert Clark, electronics technician; and Glen Hovland, pilot and camera man. Seven of the 13 balloons were specified as double-wall 1-mil type equipped with a duct appendix, as experience on the balloon project had shown that this type of balloon was a very reliable vehicle and some sacrifice in ceiling altitude was accepted in order to use this heavier balloon which would increase reliability. Also it would give comparative data with similar flights at higher latitudes for balloon flight information. Five of the balloons were 1.5-mil single wall where maximum altitude was a prime consideration. The other balloon was a type 734-AH manufactured by General Mills, 2-mil in thickness and was flown for balloon project information to compare with a similar balloon at higher latitude. Duct appendices were used on all of the flights to study the performance of the duct and to assure that the balloon would descend at sunset and to be sure the balloon would reach its initial theoretical ceiling. The effect of the duct in excluding air which might cause some increase in instability over an open bottom balloon was to be compensated for by ballasting continuously by evaporating a cake of dry ice. The results of this particular form of ballast are discussed in this report. The details

of the flights are presented in the balloon flight data chart and in the flight summaries, but in general it may be said that the operation was very successful both from the balloon stand point and the scientific standpoint. It was economical in time and expense and valuable data was obtained on meteorological trajectories as well as cosmic ray data and balloon performance data. Furthermore experience was gained in launching balloons on a field trip. The balloons and scientific equipment were transported from Minneapolis to Pyote by commercial moving van under government bill of lading, which procedure turned out to be extremely satisfactory. The equipment could be carefully packed by the movers at each end and transported with a minimum of rough handling, and in fact all equipment arrived at the launching site in perfect condition. Personnel went by commercial airline, in one of the balloon project vehicles and in the tracking planes operating under the University and Winzen Research. With the exception of one severe dust storm which held up the operation one day, the period chosen for the operation gave very favorable weather with clear skies most of the time and low winds at sunrise to favor the launching. The upper winds were also moderate and westerly and the flights which reached an altitude of between 80,000 and 90,000 feet in general, dropped from 150 to 300 miles from the launching site in an easily accessible part of Texas.

The trajectories and a discussion of meteorology are included in this report. The report also includes a discussion of the instrumentation furnished by the balloon project. The description of the scientific apparatus and the results are reported as usual in the scientific journals and meetings of the American Physical Society in accordance with the practice under the cosmic ray project.

Hitch-hike loads were flown on many of the flights for Princeton University, University of Chicago, University of Rochester, and the Canadian National Research Council.

Also included is a section summarizing the principal characteristics of the time-altitude curves, in which these flights are compared with summertime flights at Minnesota.

Use is made in this analysis of the data obtained on step flights which constitutes a very powerful way to measure the effect on the balloon of the radiation field at various altitudes and to measure the thermodynamic and aerodynamic drags at various rates of rise. This technique will be discussed in detail in a later volume of this series but because of its importance it has been applied to these flights and preliminary results are included in this report, Section XI.

Section II

INSTRUMENTATION

The majority of the instrumentation flown on the Texas flights was new, the result of improved design on older apparatus, and therefore some of it was unproven in flight. The chart in Table I shows the equipment flown on each flight.

The Olland Cycles used were the type described in Volume V[1]. These were the first flights made with this type of Olland Cycle and because of experience gained from them immediately after the series further improvements were made in this instrument. The need for a high impedence relay and high voltage between the pen arm and the rotor became apparent when on several flights the Olland Cycle became stuck open by microscopic dirt or possibly corrosion on the surface of the rotors. Flights 109 and 113 were very bad in this respect, and the records of flights 101, 102, 104, 108 and 112 each had sections of varying length obscured. Flight 107 evidenced the opposite effect - the relay failed to open properly on a few cycles. This was probably due to a permanently magnetized relay and the solution to this problem is careful adjustment of the armature core spacing of each relay during preflight preparation. Despite these troubles, sufficient altitude information was obtained on all flights.

The secondary Olland Cycles listed in column 2, Table I, were cycles with special circuitry to allow them to be flown in certain pieces of cosmic ray gear so that their data was recorded with the cosmic ray information. One of these cycles was recalibrated in the laboratory in order to check its reproducability after the equipment was returned. It was found that after shipment to and from Texas, after it had been flown, after a considerable amount of handling and storage for three months, the calibrations were identical within the scatter of points about the line on the original calibration, or approximately

[1]University of Minnesota PROGRESS REPORT ON HIGH ALTITUDE BALLOONS covering period June 22, 1952 to December 15, 1952. Volume V, pp. VII-261 - 267.

Table I

Flight No.	Olland Cycle 1	Secondary O.C. 2	Transmitter 3	Antenna Dropper 4	Telemeter Recorder 5	Down Camera 6	Camera Blowdown 7	Timers 8	Low Altitude Release 9	Flasher 10	Ballast Drop, pressure 11	Gondola Frame 12	Dry Ice 13
101	X		X	X	X	X	X		X			X	X
102	X		X	X	X	X	X		X	X		X	X
103	X		X	X	X	X	X		X			X	X
104	X	Z	X	X	X	X		X	X			X	X
105	X	Z	X	X	X	X		X	X			X	X
106	X	Z	X	X	X	X		X	X			X	X
107	X		X	X	X	X		X	X			X	X
108	X		X	X	X	X		X	X			X	X
109	X			X	X	X		X	X			X	X
110	X		X	X	X	X		X	X			X	X
111	X		X	X	X	X		X	X	Z	X	X	
112		Z			Z	Z		X	X				
113	X		X	X	X	X		X	X			X	

X = Apparatus flown in balloon project gondola

Z = Apparatus flown in cosmic ray gondola

1/5 mb at altitude.

The transmitters listed in column three, Table I, are discussed in another section of this report along with telemetering results. The antenna dropper used on these flights was the same discussed in Volume V[1]. No modifications were made and in all cases the dropper worked without fault. All pressure-operated equipment, including droppers, was tested after shipment to Texas and before flight in a special portable plastic bell jar designed and built here.

The telemeter recorder used on all flights is described in Volume V[2] and for the most part functioned well. The pinhole in the camera used on flight 103 was too large allowing considerable spread of the light on the film and while this reduced accuracy, it still furnished a readable record. This camera contained the first flight film telemetering recorder made and the other models were considerably improved. Probably because of circuit inaccuracies no record was made on flight 101. In flight 112 the camera was mounted directly in the cosmic ray gondola and no olland cycle record was made as the proper circuits were not readily available. Unfortunately it was not possible to check the circuitry on flight 101.

The cameras listed in column 6 are the same as those described in Volume V[3]. On flight 104 the film slipped in the camera for a bout the last eighth of the flight and the first 1/5 of flight 112 was simularly faulty. This error is traceable to the tension on the take-up spring belt and results in an unreliable time base for the down pictures. The trouble on flight 104 could be blamed directly on preflight adjustments, but the camera on flight 112 had been used on one flight and on a film-load duration test, without a careful mechanical checkup such is regularly given between flights, and a lack of perfect adjustment is understandable under those conditions. The other cameras worked

[1]PROGRESS REPORT ON HIGH ALTITUDE BALLOONS, Volume V, pp.VII-244 - 247.
[2]Ibid, pp.VII-224, 232 - 233.
[3]Ibid, pp. VII-224, 231 - 233.

without fault and an adequate film was derived from every flight.

The camera blowdown listed in column 7, Table I, is described in Volume V[1]. Flights 101, 102 and 103 which used this method of timing exclusively did not come down as expected and it was thought that the timers were failing, so the camera blowdown timers were cut out on all succeeding flights. It was later found that the timers were in operating condition but that the film load had been made too long in expectation of a lengthy check out period, whereas actually the check out time, at least on the cameras, was kept to a minimum.

The clock work timers (column 8) substituted for the camera timers were a pair of Minneapolis Honeywell timers used previously by this project, which were incorporated in a box with a dry cell and a low altitude blowdown mentioned in Volume I[2]. This combination was flown as a unit in a glass wool insulated bag external to the project gondola at the point in the equipment train where separation from the balloon was to be made at blowdown. In all cases this blowdown box functioned as planned.

The flashers flown on flights 102 and 111 were new with these flights and consisted of three No. 47 lamp bulbs connected in parallel and enclosed in a thick plastic container with a thin red plastic filter, which were driven by an electromagnetic oscillator made in the Physics Department shop and copied after the element in the Dayco flasher mentioned in Volume V[3]. These flashers had a light output measured at 6.5 foot candles at one foot, and an oscillation rate of $1\frac{1}{4}$ per second. As far as is known these flashers worked well on these flights. On flight 111 the flasher was located in the cosmic ray gondola for convenience.

The ballast dropper used on flight 111 was the pressure operated type described in Volume V[4]. It worked during the flight as intended and released a load of cosmic ray gear flown as ballast.

1 PROGRESS REPORT ON HIGH ALTITUDE BALLOONS, Volume V, pp. VII-233
2 Ibid, covering period December 13, 1951 to June 15, 1952, Volume I, pp. 5-1, 5-3.
3 Ibid, covering period June 15, 1952, to December 22, 1952, Volume V, pp. VII-208, 211.
4 Ibid, Volume V, pp. VII-218 - 221.

The gondola frame (column 12) was a solid rectangle 12" square and 10" high topped by a pyramid 45° in cross section, and was constructed of 1/16 x 1/2 x 1/2 aluminum angle with corner webs. The gondola frame was encased in a four inch styrofoam box and this was covered with a heavy canvas case with zipper closures and dyed bright orange. A metal reward tag was riveted to this case and a Spanish translation fastened below it. This assembly was used on all flights except flight 112 where all flight control equipment was located in the cosmic ray gondola.

A block of dry ice was flown on the flights indicated in column 13 as a ballasting device. This block was contained in a special fishnet bag and hung within the field of the down camera in order to record the amount of evaporation. There was a screw eye fastened to the bottom of the gondola to allow the easy attachment of this dry ice.

The preflight gondola pictured in Figure 1 is typical of flights 101 and 103. Figure 2 is the gondola flown on flight 102 and the gondolas flown on flights 104, 105, 106, 107, 108, 110 and 111 were similar to that shown in Figures 3 and 4. The timer and low altitude release box is also shown in these pictures. There are no preflight pictures of the gondolas flown on flights 109 and 113, and there was no gondola on flight 112. The wiring diagrams follow on the next few pages. They are intended to show the various units included on each flight and the interconnections in graphic form. Detailed circuits are given under the description of the individual components in this report and in other volumes of this series as footnoted.

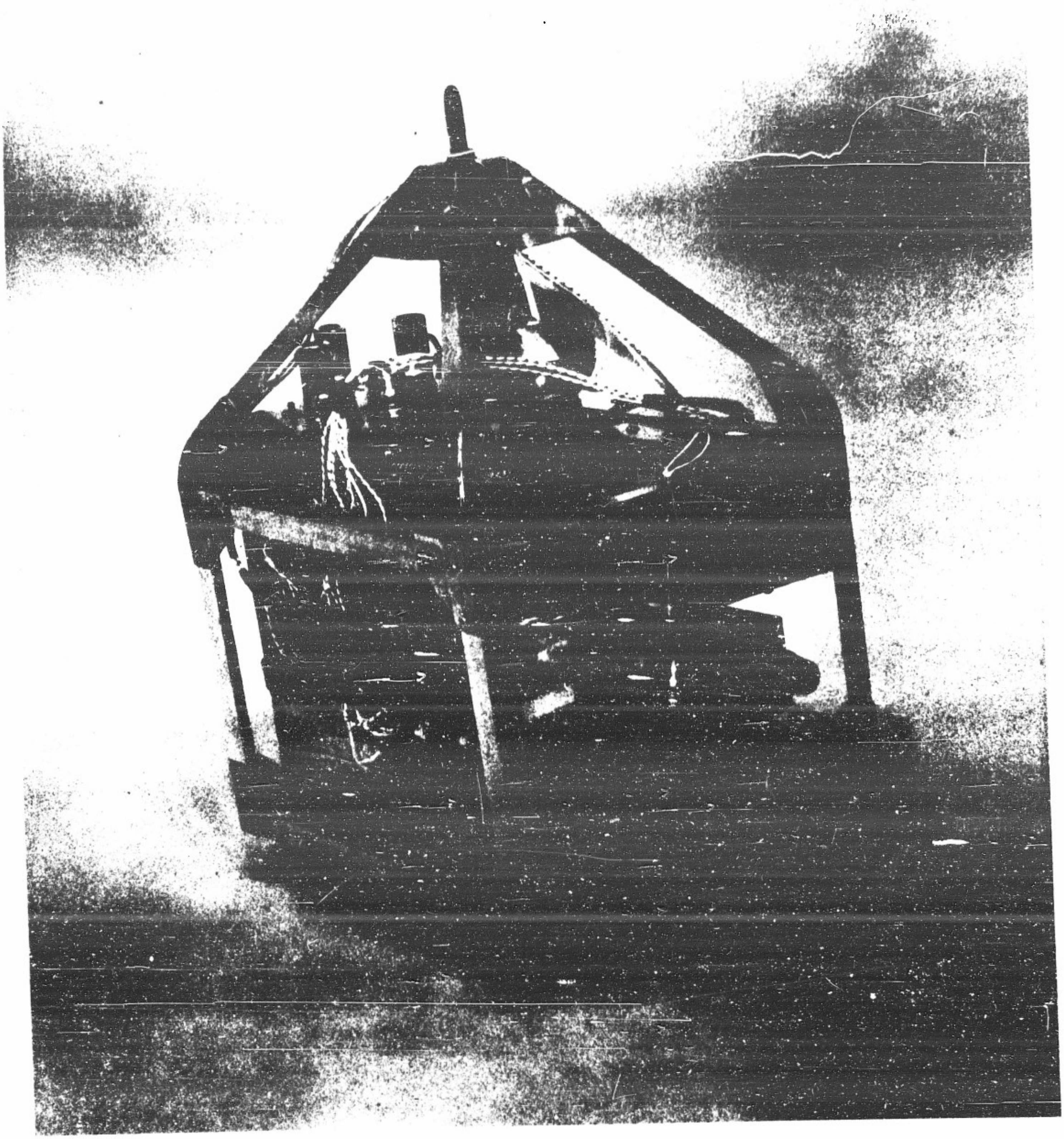


Figure II-1. Preflight gondola picture - typical of flights 101 and 103.

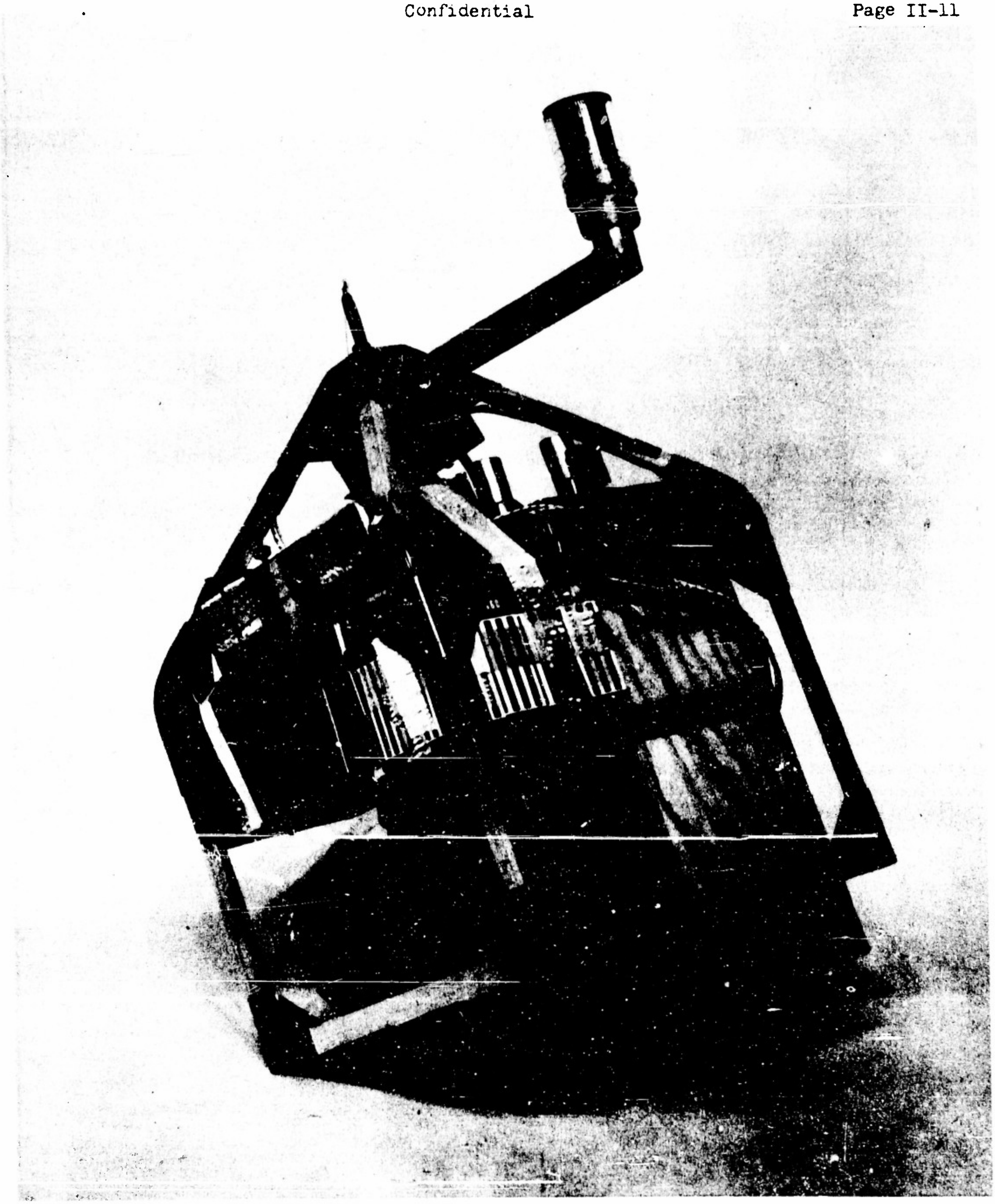


Figure II-2. Preflight gondola picture of gondola flown on flight 102.

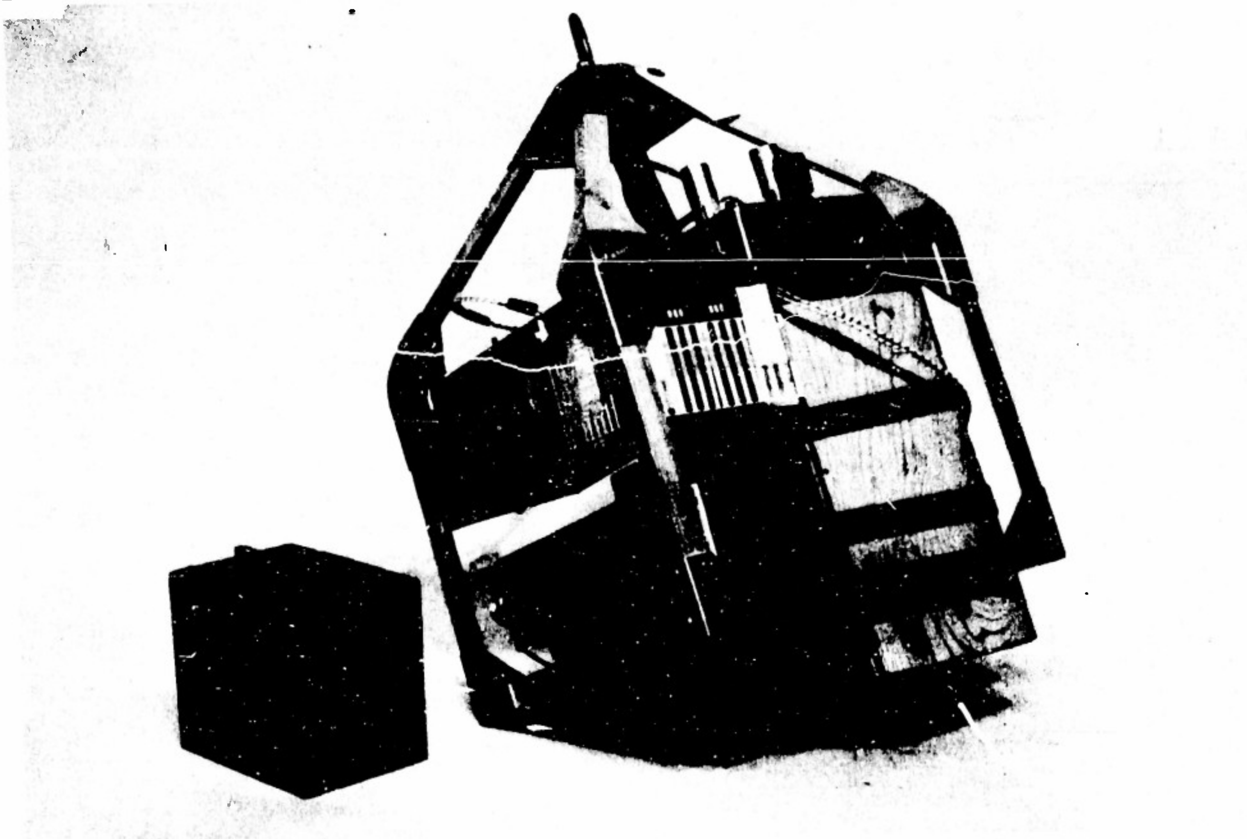


Figure II- 3

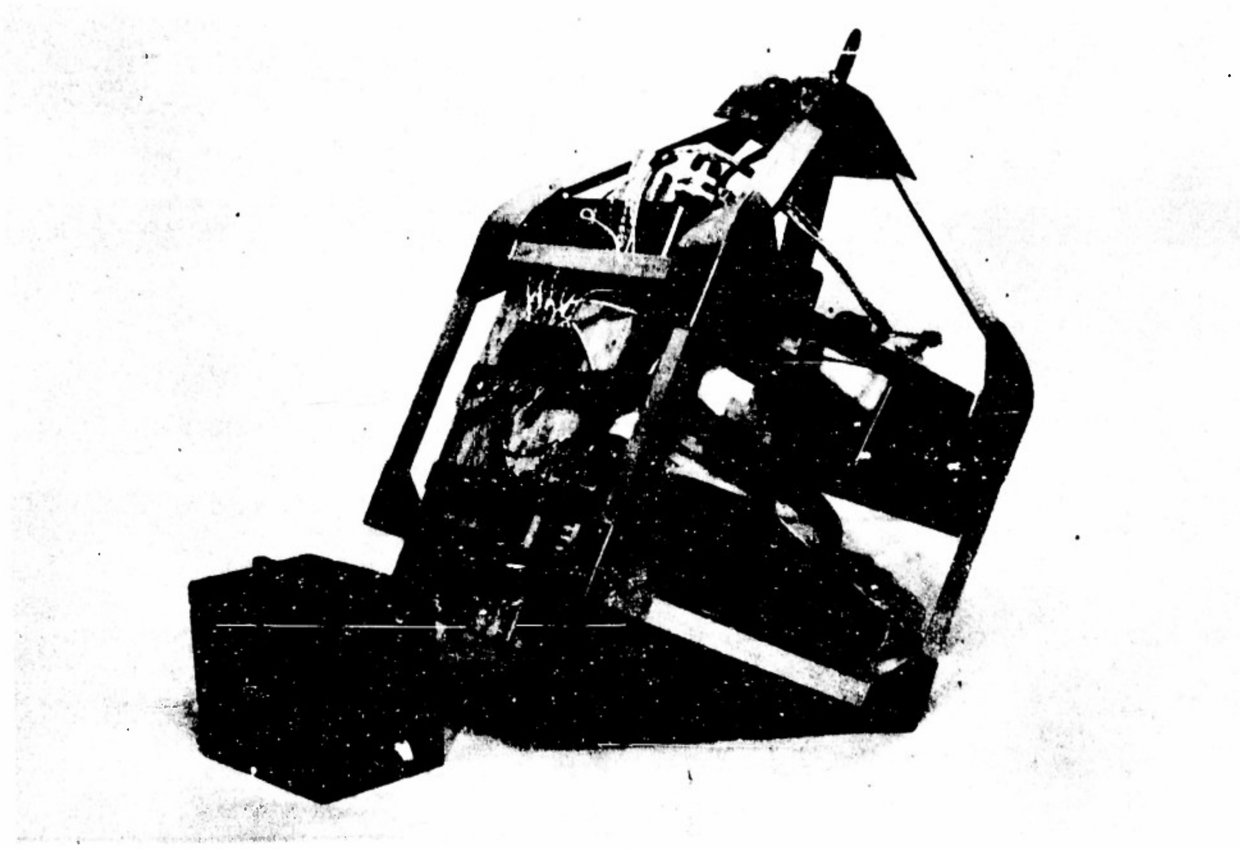
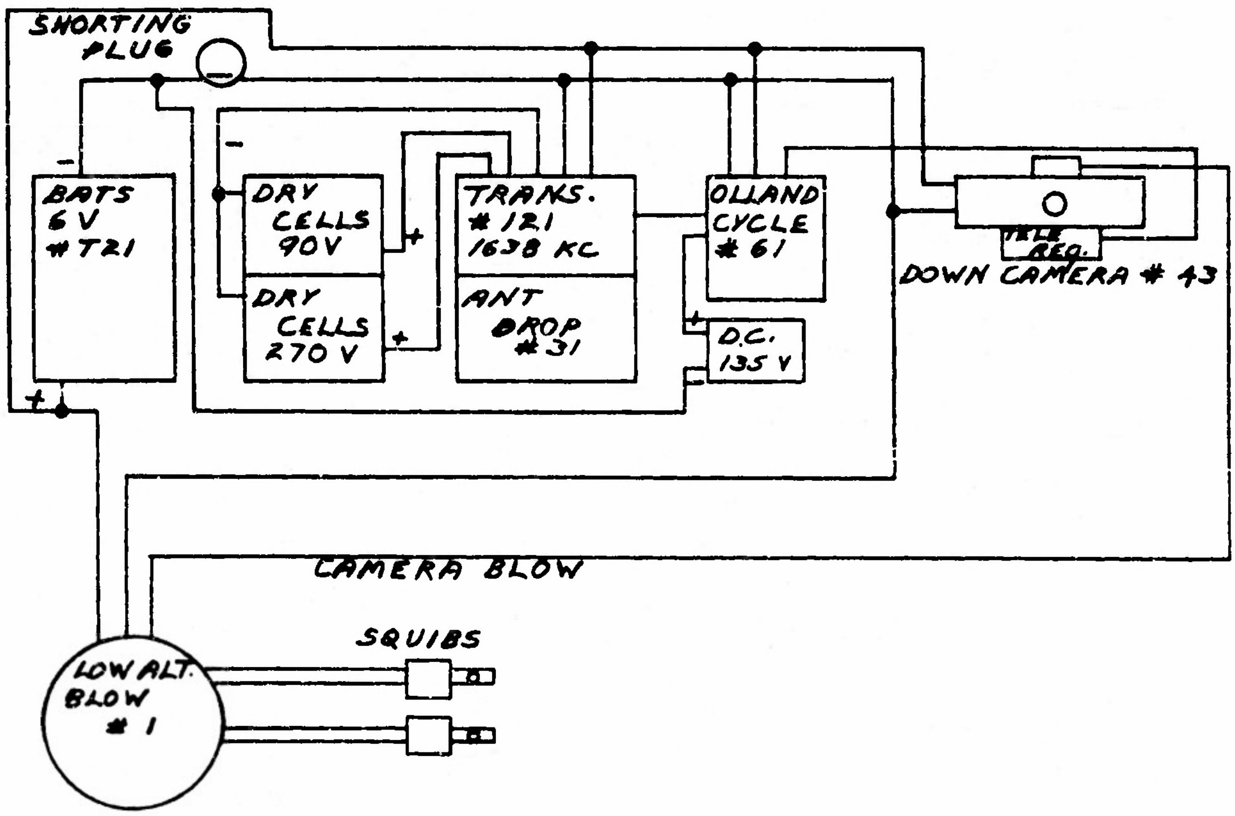


Figure II-4

Figure II-3,4. Preflight gondolas similar to those flown in flights, 104, 105, 106, 107, 108, 110 and 111.



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GONDOLA # 151			MOD. 2	
			MOD. 3	

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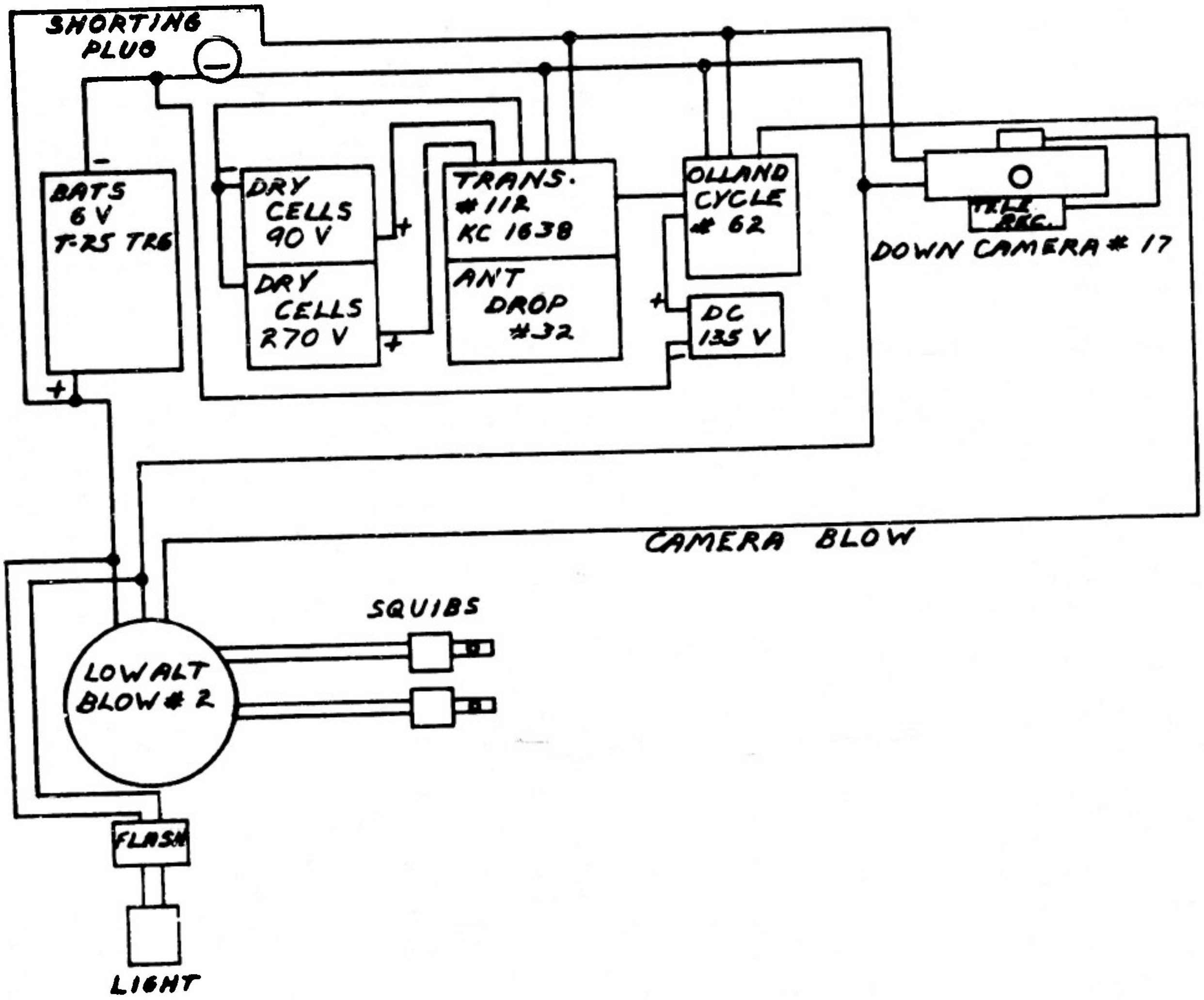

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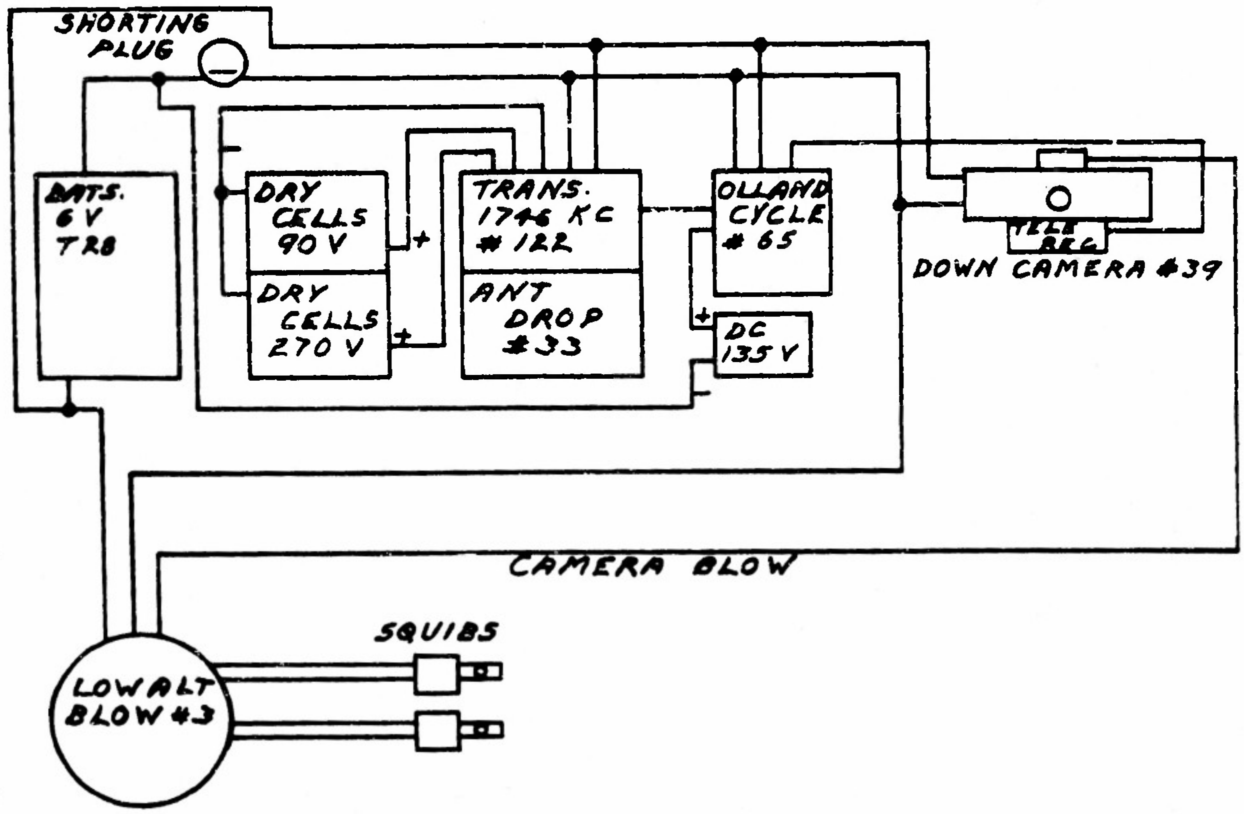
FLIGHT #102 (TEXAS)
GANDOLA # 152

MOD. 1
MOD. 2
MOD. 3



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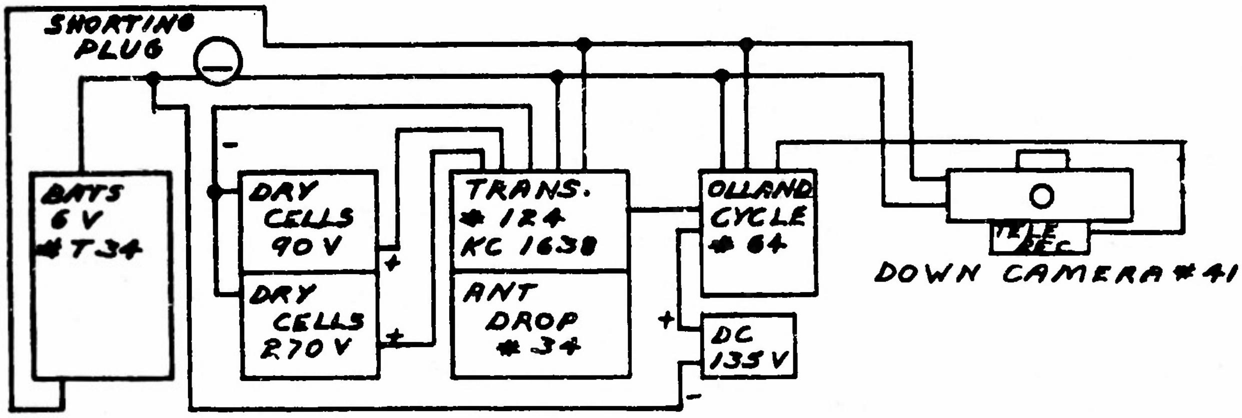

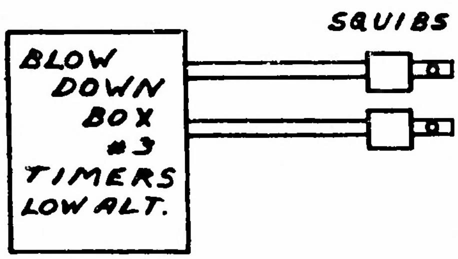

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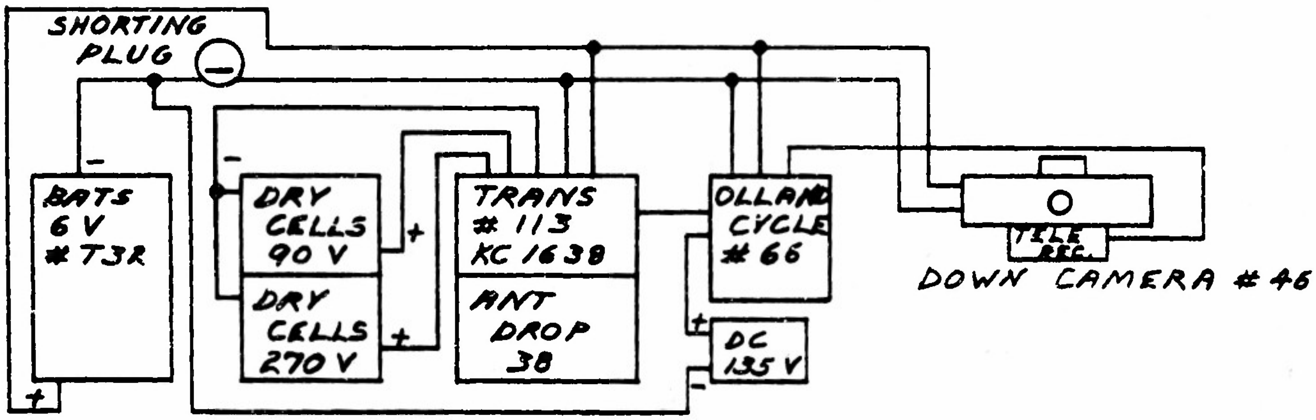
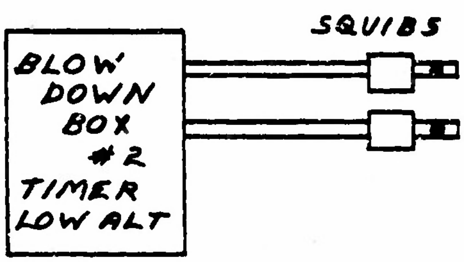
Confidential Security Information			MOD. 3	





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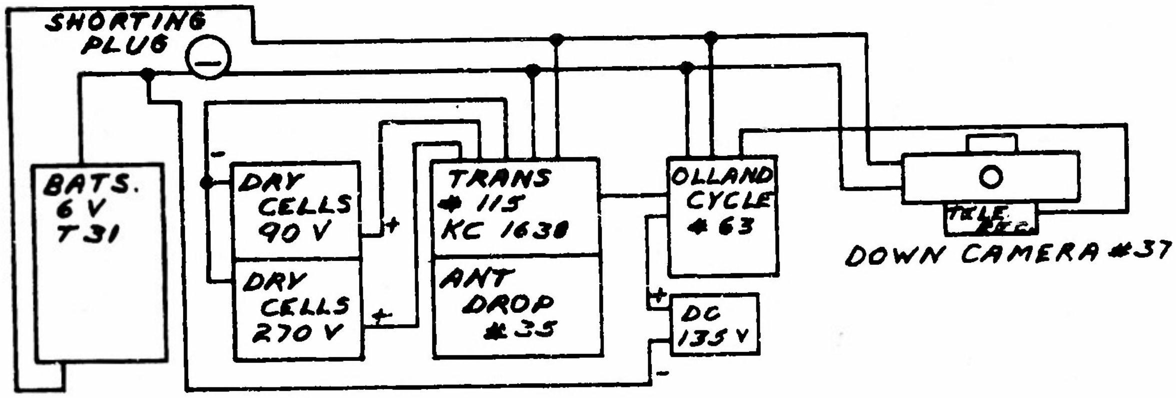
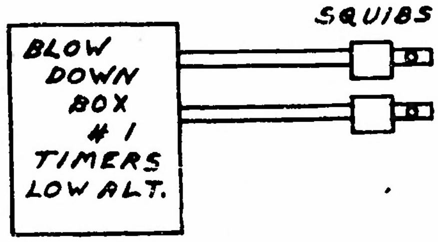
Confidential Security Information			MOD. 3	





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			MOD. 2	
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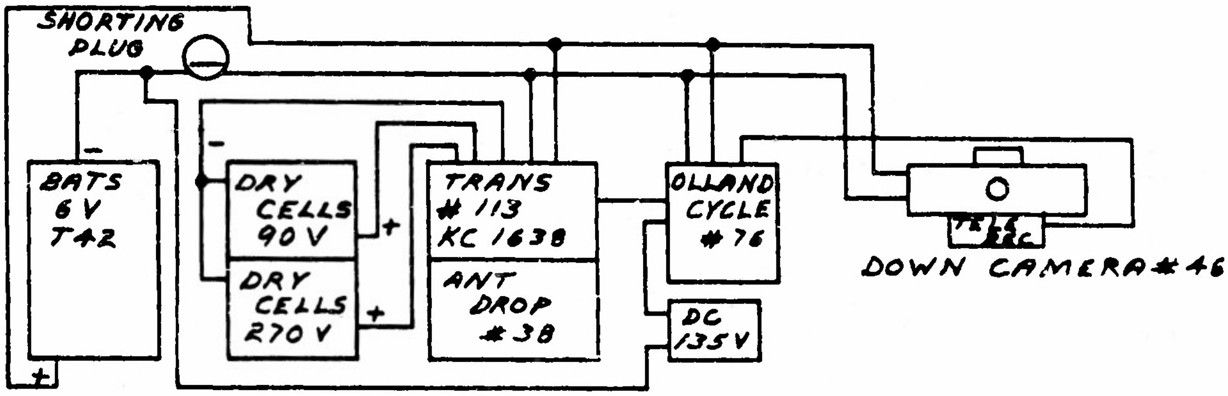

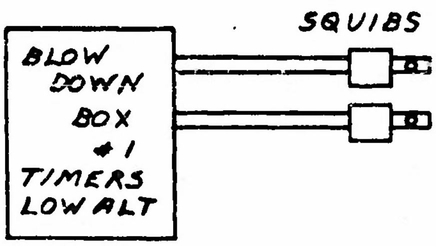

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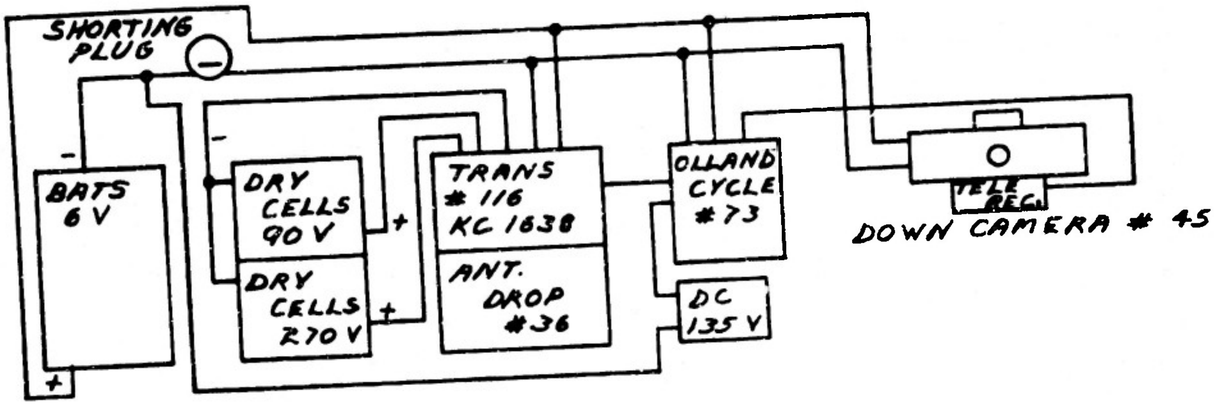

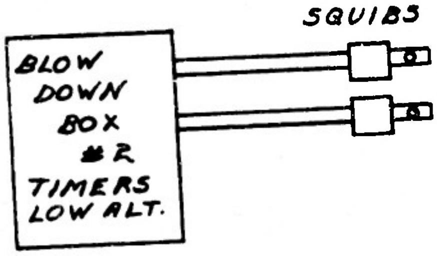

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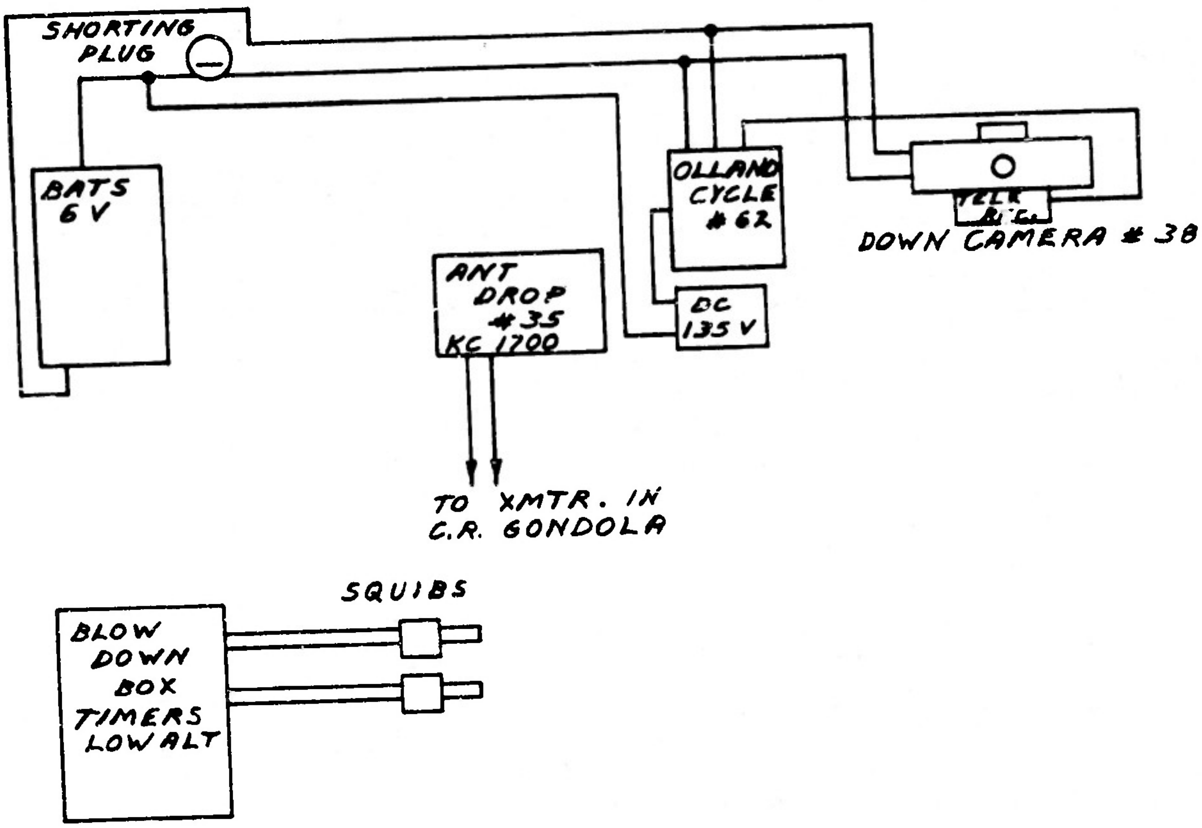

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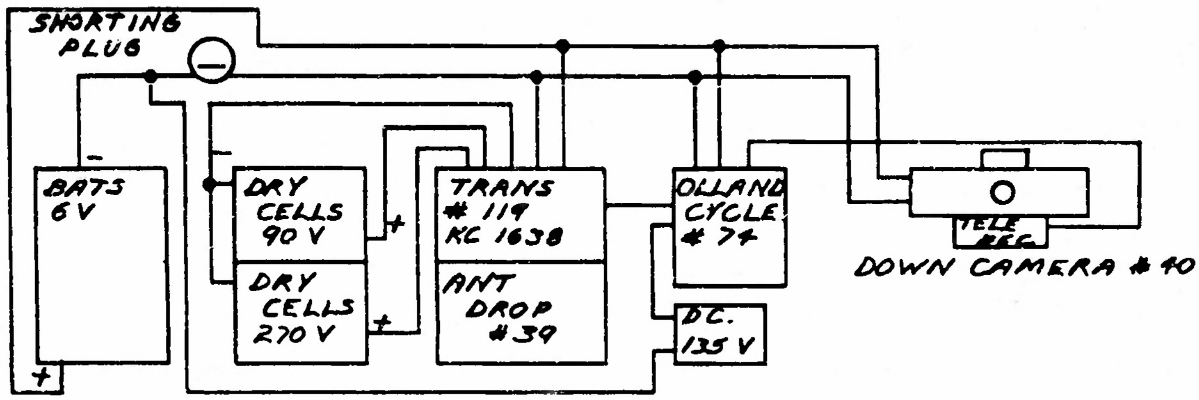
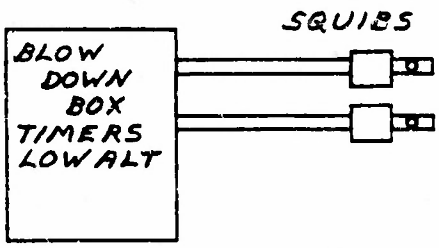
			MOD. 3	





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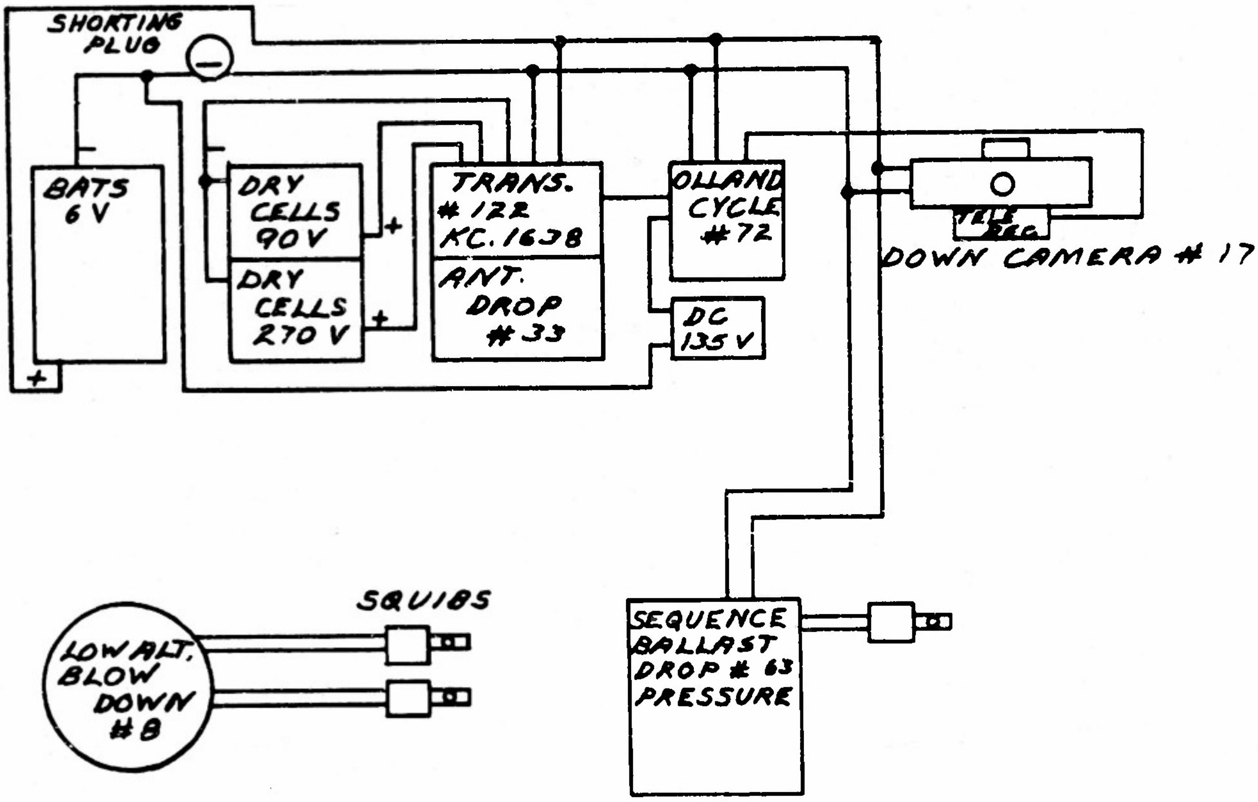
			MOD. 3	



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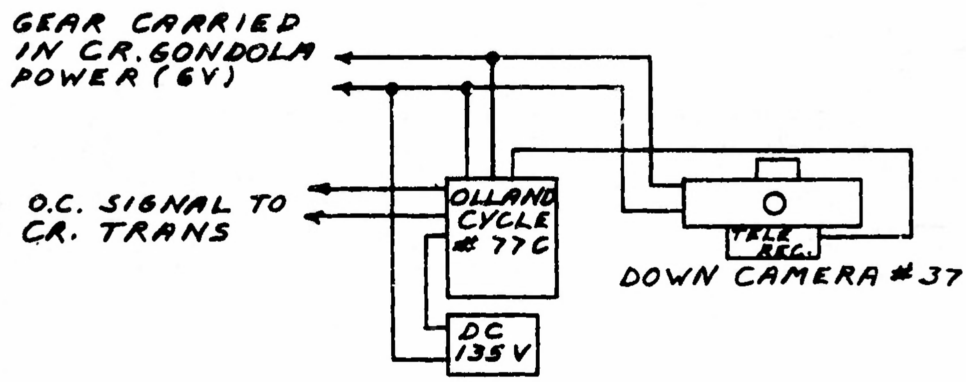

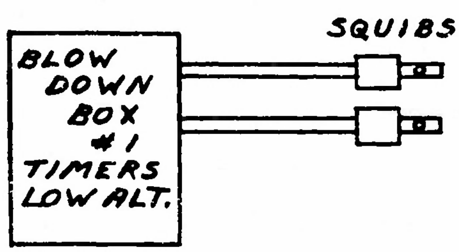

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			MOD. 2	
			MOD. 3	

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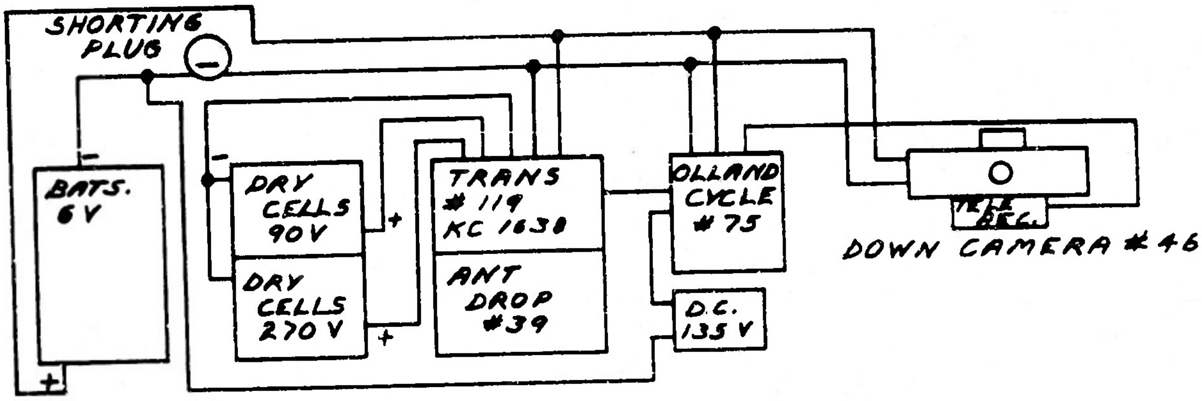
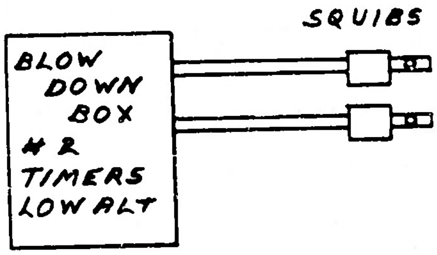




DEPT. OF PHYSICS U. OF MINN.
BALLOON PROJECT SECT. INST.

DWG. NO.	SHOP DWG. NO.	DRAWN BY	CHECKED BY	DATE
				2-4-53
FLIGHT #113 (TEXAS)			MOD. 1	
GONDOLA # 159			MOD. 2	
			MOD. 3	

Confidential Security Information

Section III

RADIO TELEMETERING (TEXAS FLIGHTS)

The telemetering furnished by the U. of M. for the series of flights consisted of single-channel C.W. pulse transmission. The information telemetered was the air pressure at the balloon altitude as encoded by the Olland Cycle[1] mechanism.

The type transmitter[2] used, in this series, consisted of a push-pull crystal- controlled oscillator and a push-pull final power-amplifier stage. The peak power delivered to the antenna[3] terminals was approximately 4-watts. Keying was accomplished by opening and closing the 90V D.C. supply to the screen grids of the final amplifier. The keying relay was controlled by the Olland Cycle mechanism, in this case, but this transmitter could be used for telemetering any slow pulse-code information.

The frequencies used in this series of flights were 1638 K.C. and 1746 K.C. It was possible to monitor two flights simultaneously on these frequencies by tape-recording one signal and observing the other on the strip chart recorder in the usual manner.

Although the pulse-type signal is not at all ideal for radio direction-finder tracking, the transmitted signal was used on several occasions by the tracking plane to locate the balloon.

As the slow pulse-code signal employed required only a very narrow band of frequencies for transmission, the signal was received in the same manner as C.W. code. The audio-frequency output at the receiver was fed into a narrow band audio filter-[4]

[1] University of Minnesota PROGRESS REPORT ON HIGH ALTITUDE BALLOONS, Volume V, p. VII-259
[2] Ibid, p. VIII-351 and Figure VIII-7
[3] Ibid, p. VIII-351
[4] Ibid, pp. VIII-345, 346 Fig. 3

amplifier where a large portion of noise could be removed.

The transmitted power appeared to be adequate for good reception for at least 90% of the total flight time during the series. The distances involved were not long, but in some cases the balloon was over line-of-sight range. The following page is a schematic diagram of the transmitter used in the 13 Texas flights.

Confidential

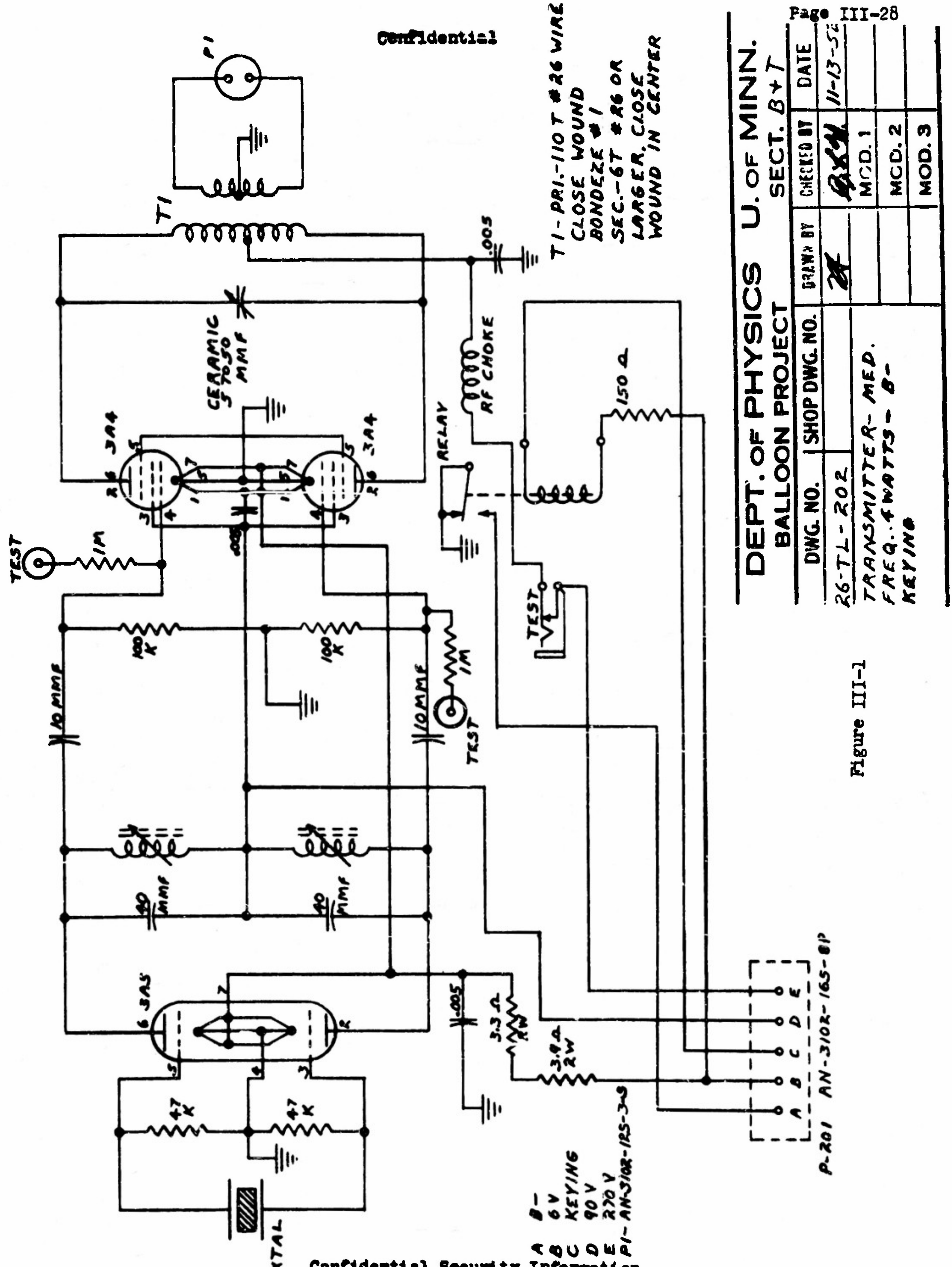


Figure III-1

Confidential Security Information

Section IV

FLIGHT SUMMARIES

Flight 101

The first flight of the Pyote operation was launched January 20, 1953, at 0814 CST. This flight was to carry a cosmic ray plate mover with nuclear emulsions and it was desired to get as good an altitude as possible. To meet this specific requirement a 1.5-mil balloon, Winzen no. 73-150V-266 with glass filament tapes and a duct appendix was used. In addition to Naugle's plate mover the balloon carried balloon project gondola #151 containing transmitter, antenna dropper, Olland Cycle, down-camera and camera blow-down with the usual low altitude release for cutting off the balloon if it descended below 30,000 feet to meet CAA requirements. Twenty-four pounds of dry ice was also carried as ballast. A Geiger counter sonde was also carried as hitch-hike load from Princeton University. The balloon was weighed off somewhat light although it was not realized that it was dangerously so until the flight had been released and the balloon rose into the stratosphere. The rate increased from an initial value of 910 to 1600 feet per minute and when the balloon reached ceiling the rate exceeded this. The time-altitude curve shows that the balloon began an immediate descent upon reaching ceiling and descended to about 50 mb at which time it decelerated and leveled off at about 70 mb where it remained for the rest of the flight. The indication from the time-altitude curve is that the high rate of ascent super-pressured the balloon enough to make it rupture near the bottom, probably where the cone-sphere junction occurs. This allowed an escape of gas and the balloon descended so that the lifting gas zero pressure level moved above this point. The balloon then continued to descend and air came in through the opening finally stabilizing the balloon so that it leveled again. The balloon was found floating in the gulf near Port Arthur, Texas. The apparatus was not found despite extensive air search,

but was reported in about four months after the launching time in the city of Nemo, Texas. The load upon recovery was in excellent condition but the time-altitude curve did not meet the requirement of the cosmic ray experiment, which was to investigate the Z spectrum of heavy nuclei in the primaries. These are not present at the altitude at which the balloon floated for most of the day.

Conclusions

We are confronted here with a large increase in velocity as the balloon ascends. It was suspected that there was a considerable increase in superheat as the balloon gained altitude and that weigh-offs would have to be kept low at Pyote in order to insure the balloon having a safe velocity at reaching ceiling.

Flight 102

Flight 102 of the Texas series was launched also on 20 January 1953 at 1734 CST. The purpose of this flight was to carry an emulsion stack with lead and paraffin for 24 hours at high altitude. The balloon used was a Winzen double wall #73-2x100-V-260 with glass filament tapes and duct appendix. The balloon was weighed off with a free lift of 8% of the displaced air. Due to a failure of the Olland Cycle and apparntly also of the down camera, no record was obtained on ascent. The Olland Cycle came on when the balloon leveled following sunset but it was then found that the balloon had leveled well below its ceiling at 86,000 feet. It floated at 70,000 feet (47 mb) at a very constant level from 1900 until 0100 the next morning when it began a very slow descent. At 0500 it speeded up and went through the tropopause at 0700 and came rapidly down. The load with the balloon attached was recovered six miles south of Peacock, Texas. It was found that the low altitude release had operated but the squibs had not blown apparently because the wires leading up to the squibs had twisted off as the gondola rotated under the balloon. Some dry

ice was still on the load and vapor was seen as the balloon descended. Despite the fact that the flight was shorter than anticipated and did not go to quite as high an altitude it was a useful flight for the purpose and the plates are to be analyzed.

Conclusions

The balloon was weighed off with insufficient free lift for the purpose. In other words, the sunset effect was worth at least 8%, ~~which was~~ the ground weigh-off, unless there were changes in this free lift as the balloon rose due to the time of day. There is also indication on this flight that the tape construction on the top of the balloon may have failed when the heat of the sun warmed up the tapes the next morning permitting them to slide somewhat and open a hole in the balloon top, because the descent at sunrise instead of the expected ascent is indicative of a leak. The initial failure of the Olland Cycle was supposedly due to poor contact by the reference arm which interrupted the circuit and kept the transmitter on all the time. that This corrected itself.

Flight 103

Flight 103 was launched the 21 of January 1953 at 0832 CST and like flight 102 used a double wall balloon no. 73-2x100-V-258 made with #890 tapes with a duct appendix. The flight was to carry a counter hodoscope constructed by John Linsley and the flight time was supposed to be 10 hours. The balloon was launched with a free lift of 40 pounds or 6.5% of the air displaced and it rose at 730 feet/minute initially. At ceiling it was moving at 1330 feet/minute but it reached the correct theoretical ceiling, leveled off and remained level at 26 to 28 mb until 1600 when it began a slow descent. At 1820 it began a rapid descent at 292 feet/minute, went through the tropopause at 1920 increasing its rate to 639 feet/minute. The load cut loose on the low altitude release at 2000 and was recovered at Altus, Oklahoma, just over the Texas border. In this case the termination timer failed to operate

but it was quite clear that the operation of the duct appendix brought the balloon down,and let the load on the ground not very far from the point at which it would have dropped from high altitude.

Conclusions

This is an excellent scientific flight in which the balloon floated level at theoretical ceiling most of the day. There was a failure of the release timer which was traced back to the camera blow down not operating but the load was recovered and it is therefore a very satisfactory operation. The sunset rate of descent is approximately that observed in Minneapolis in similar balloons. The change in velocity at the tropopause is also in agreement with expectation.

Flight 104

Flight 104 was launched January 23, 1953, for the purpose of carrying a large cosmic ray telescope furnished by Winckler. A double wall balloon was used, no. 73-2x100-V-269 and the theoretical ceiling was 81,000 feet which was reached following a good launching and ascent curve which reached 1200 feet/minute. The balloon descended right after reaching ceiling from 26 to 35 mb where it floated level until released by the timers at 1640. The leveling off may have been due to the dry ice ballast evaporating. This was a very excellent scientific flight.

Flight 105

Flight 105 was launched January 24, 1953, at 0755 CST. The purpose of the flight was to obtain albedo and geomagnetic data with the Čerenkov counter of Winckler and Anderson. The balloon was a 1.5-mil #73-150V-265 made with glass filament tapes. The theoretical ceiling was 84,000 feet. The free lift was weighed off to 4.6% of the displaced air and the flight had a very satisfactory

ascent curve. After reaching ceiling it floated level until 1500 when it began a slow descent until it was released by the timers at 1715. This was a very excellent flight for the scientific requirement. The balloon was equipped with a duct appendix. The flight carried actually two Olland Cycle instruments, one in a cosmic ray gondola and one in the balloon project gondola and both of these are plotted on the time-altitude chart. It is believed that the one in the cosmic ray gondola, in this case, gives the correct readings from a number of independent bits of evidence about this flight. This Olland Cycle indicated a pressure which is two to three mb lower than the one in the balloon project gondola. It is interesting that for the first two hours of flight the Olland Cycles were in perfect agreement. Towards the end of the ascent portion of the flight they separated and seemed to come together more towards the end of the flight where it had settled somewhat. They also follow together over a number of fluctuations particularly right after the balloon reached ceiling, showing that often these fluctuations often observed in Olland Cycle records are real and not associated only with the instrument itself. This flight carried 23 pounds of dry ice ballast.

Flight 106

Flight 106 was launched 26 January 1953 with a one day loss in time due partly to instrumentation difficulties with a scientific load and partly to an overcast condition. This flight carried the other Čerenkov apparatus and used a 1.5-mil balloon #73-150V-268 with glass filament tapes. The theoretical ceiling was 86,500 feet. The balloon had a normal ascent curve to about 67,000 feet where it apparently opened a hole, began a rapid descent and came all the way back to the ground again. The balloon was observed through the theodolite and on the descending part was swinging with a large amplitude of perhaps $\pm 30^\circ$. The load was eventually released on the low altitude blow down and was recovered after an air search near Big Lake,

Texas. The balloon drifted on and was sighted at the San Angelo area where it was spotted by an air force plane which established contact at 19,000 feet. The balloon then descended and was picked up by the air force personnel. The scientific apparatus was in excellent condition and was subsequently reflown on a later flight. The cause of the balloon failure is not known.

Flight 107

Flight 107 was launched on the 30 of January, 1953, at 0845. Intervening days were occupied with several other flights sent up by Winzen Research for other universities. Flight 107 used a 1.5-mil balloon #73-150V-263 with a ceiling altitude of 88,000 feet and a plate mover supplied by Naugle. The balloon reached the theoretical ceiling at 88,000 feet and floated nearly level throughout the day with a very slight downward rate from 21 mb from the start of the flight to 27 mb at the end of the flight. At 1731 it was released by timers. This flight is representative of the best in SKYHOOK flights throughout the series. The balloon was weighed off to 10% of the displaced air and had a velocity, upon reaching ceiling, of 1120 feet per minute. The flight carried 29 pounds of dry ice as ballast.

Flight 107 was one of a pair of twin flights which were launched simultaneously on January 30. The plates have now been analyzed and data is being assembled. The results may be described as completely successful.

Flight 108

Flight 108 was also launched the 30 of January and was the second member of the twin launched. The pay load was a scintillation counter prepared by Horwitz and the balloon was a double wall #73-2x100V-249 with duct appendix and nylon filament tapes. This flight was weighed off to a free lift of 7½% of displaced air and was an excellent flight. It leveled off at theoretical ceiling and then descended from the initial

24 mb to 28 mb by 1300, climbed back again to 26½ at 1500 and then dropped to 33 mb by release time at 1730. It is noteworthy that the two balloons in the twin launch left the ground together and remained practically together up to about 40,000 feet, where they were still separated by not more than one or two balloon diameters. At this point flight 107 which was lighter in gross went on ahead of 108 and, as a matter of fact, passed directly over it and photographed 108 from the camera tied on 107. This photograph is included in this report. (Figure XII-2). Photos of the twin balloon launch are shown in Figure XII-1.

Flight 109

Flight 109 was launched on February 1, 1953 at 0750 and was followed in one hour by flight 110 of the same date. Flight 109 used a double wall balloon #73-2x100V-270 with duct appendix and carried Bohl's scintillation counter with theoretical ceiling of 86,000 feet. Flight 109 reached the theroetical ceiling of 83,300 feet or approximately 20½ mb where it remained very level from 0930 until 1200. The balloon then began a slow descent and at 1620 had reached 50 mb. The signal was lost at 1650 at 80 mb. The girdle catcher was inadvertantly left off of this flight but the girdle dropping apparently did not damage any of the equipment. The parachute was observed to open but both gondola and the instrumentation gondola broke loose and free fell. This is believed to be due to the fact that the chute had opened at low altitude. This behavior has been borne out in a number of other cases in which the packed chute is opened by the low altitude release at 30,000 feet. From the stretching of the load ring which was recovered and a broken 3,000 pound nylon rope it was estimated that the acceleration of the chute opening must have been about 10 g. The flight was a valuable one from a scientific standpoint despite the fact that the balloon descended somewhat prematurely.

Flight 110

Flight 110 was launched on the same day as 109, February 1, 1953, at 0850 and carried McDonald's cloud chamber on a 1.5-mil balloon, #73-150V-264, with #890 tapes and a duct appendix. The flight did not show the large acceleration encountered on some of the previous flights. It started at 775 feet/minute and reached ceiling at 933 feet/minute. It leveled at theoretical ceiling, floated extremely level throughout the day until 1700. At 1730 the cut down actuated and the load descended on the parachute. It was recovered in good condition. This is another example of a very excellent scientific flight. The free lift was 8.6% of the air displaced.

Flight 111

Flight 111 was launched for the purpose of studying the performance of a General Mills, Inc. balloon, #734-AH, equipped with a duct appendix. The Linsley gondola flown was to be dropped as ballast following the descent after sunset. Theoretical ceiling was 84,000 feet and the balloon reached 79,000 feet according to the pressure record using the standard atmosphere. The folded bubble was too small to get all of the gas in it so that the corset had to be removed and the inflation completed. However, everything went smoothly and the flight was a good flight constants experiment for the balloon project. The balloon on ascent increased its rate from 288 feet/minute to 575 feet/minute with a slight break just ahead of reaching ceiling at 50 mb. The flight was launched at 1410 and floated level from the time it reached ceiling at 1640 until 1819 when it began the pre-sunset descent. It established a rate of 440 feet/minute and by 1840 increased to 520 feet/minute and again increased at the tropopause to 760 feet/minute. After Linsley's gondola was dropped the balloon rose at 1300 feet/minute but ruptured when it began valving and then descended at the same rate. The signal was then lost. Linsley's gear was recovered near Big Lake, Texas.

The initial ascent curve on this flight has been analyzed to determine the alt-

titude warming using the drag nomographs. This is discussed in Section XI. The ascent rate at night after ballasting is in very good agreement with the values predicted by these same nomographs.

Flight 112

Flight 112 was launched February 3, 1953, at 0813 and used a double wall balloon #73-2x100-V-259 with #890 tapes and duct appendix. The flight carried the second Čerenkov gondola and had a theoretical ceiling of 84,200 feet. It was weighed off with a free lift of 8.1% of the air displaced. In ascent, this balloon accelerated from 590 feet/minute to 1000 feet/minute and floated level at 26 mb until 1510 when it began a very slow descent and had reached 29.5 mb when the load was released by timers at 1710. This is a very excellent SKYHOOK flight and the load was recovered in very good condition.

Flight 113

Flight 113, the last of the present series, was made 4 February 1953 and launched at 0828. A double wall #73-2x100V-247 balloon was used equipped with a duct and #880 tapes. Theoretical ceiling was 81,700 feet. This flight was launched on a cloudy day and rose at 730 feet/minute initially following a weigh off of 4.5% of the air displaced. Between 300 and 100 mb the rate was 580 feet/minute which increased somewhat to 655 feet/minute up to 60 mb but then curved off and leveled considerably below theoretical ceiling at 33 mb, theoretical ceiling being 26 mb. The balloon floated quite level from 1040 until 1230 when it began a descent with a rate of about 200 feet/minute. The signal was lost at the Pyote Air Force Base at 1447. The tracking plane lost the signal at 1510. The load was presumably dropped from the balloon by the low altitude release. It was subsequently established that the load snapped off the parachute much the same as flight 109 and

that the load free fell. It was later recovered and the film record of the cloud chamber was in excellent condition. Snapping off of the parachute came about due to the release at low altitude with the result of high acceleration. We have here definitely a case of a leaky balloon but there are several features of this flight which are not clear. One is that its initial rate being higher than its final rate on the ascending portion is not characteristic of any of the other flights. The fact that it floated level makes the leakage presumably not very high but was complicated by warming during the period from 1100 to 1230, although this is not certain. This is a rather long period for warming to take place.

The following pictures, Figures IV-1, 2, 3 and 4, show various steps in the launching of one of the Texas series.

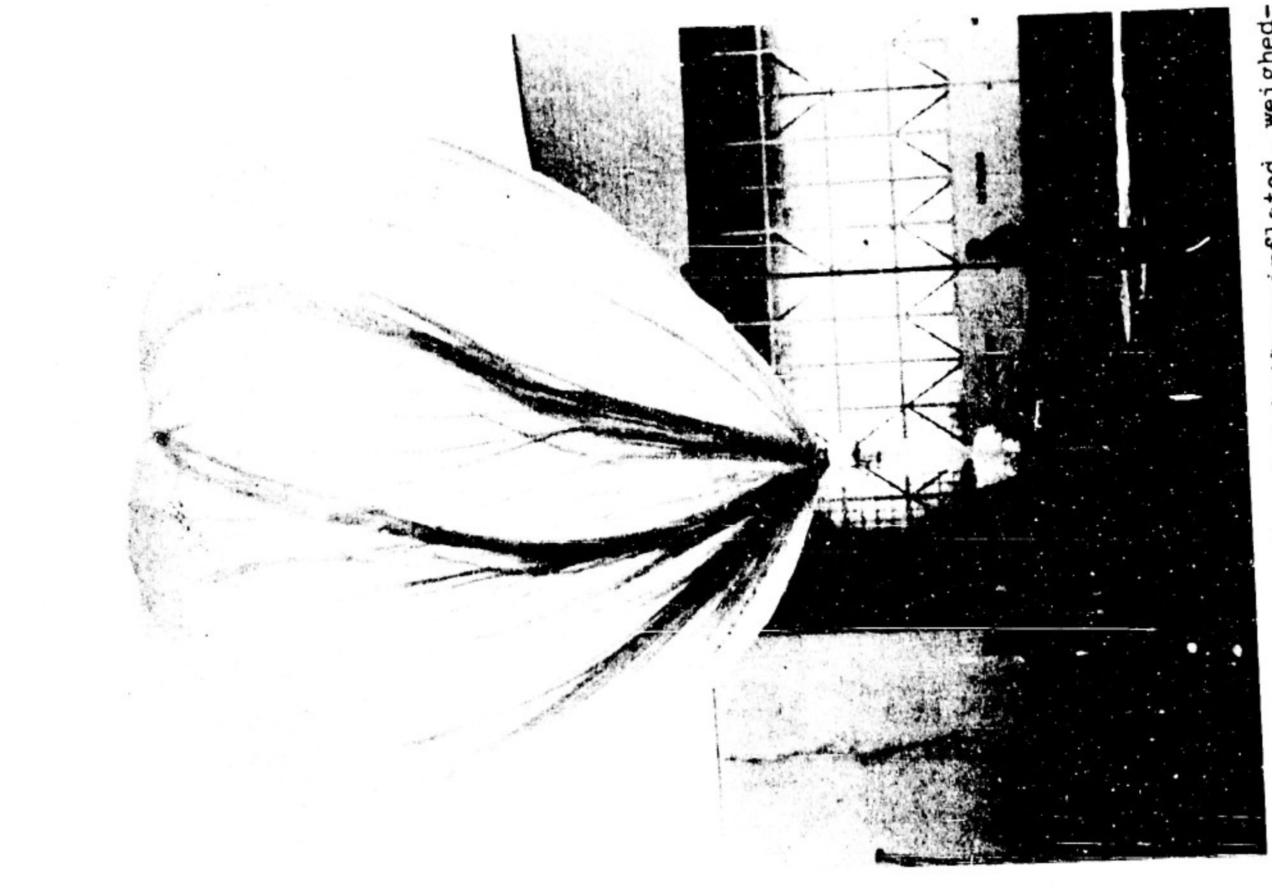


Figure IV-1. View of packed balloon inflated, weighed-off and with final adjustments being made on rigging.

Figure IV-2. Close-up of anchor point showing packed balloon and tied off appendix, left. Girdle catcher ring and timer release, lower left. Scientific apparatus being secured and turned on, right.

Figure IV-3. Inflated packed balloon ready for erecting showing mooring line and inflation hose, left. The mooring line at the upper end is out of camera view.

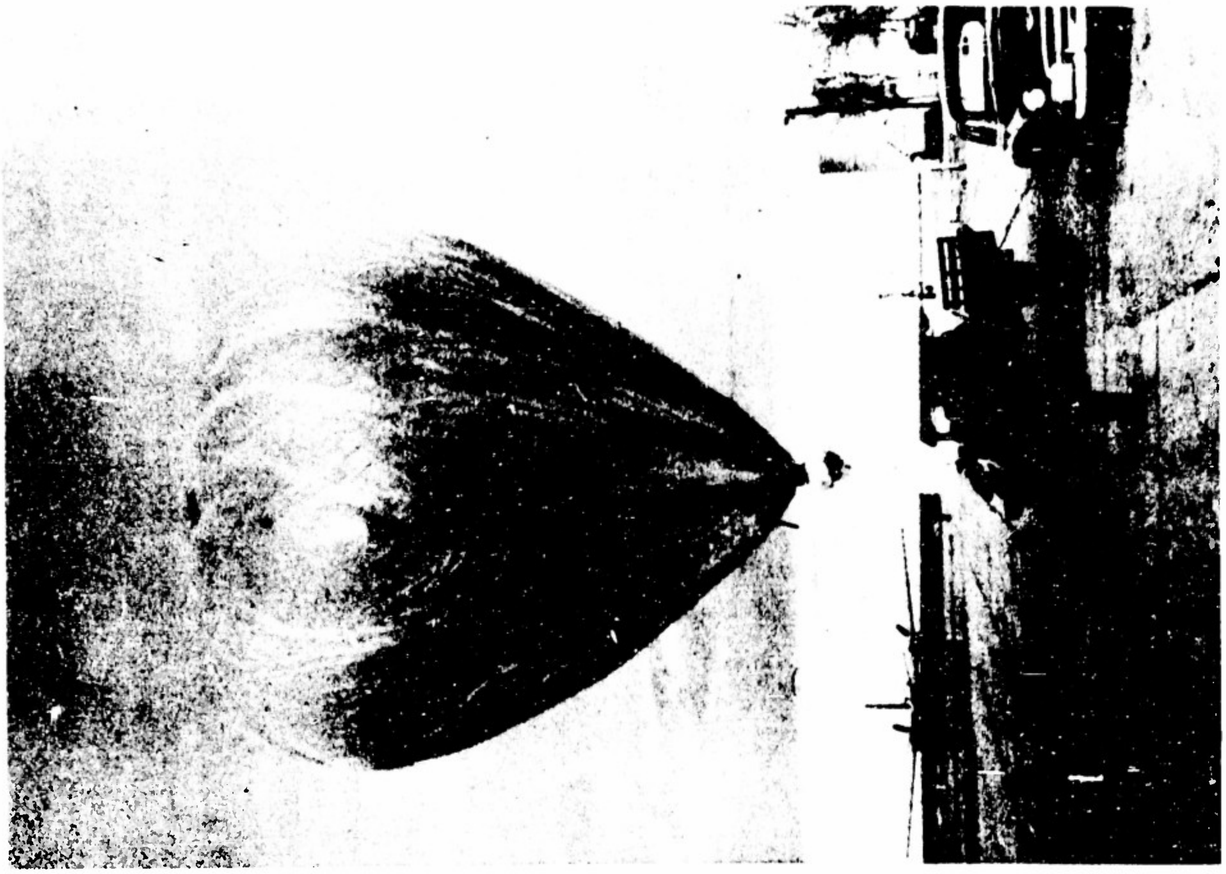


Figure IV-4. Inflated balloon being transferred by truck to hangar for storage following cancellation of flight because of difficulties with scientific apparatus. This balloon was launched the following morning and had not lost appreciable lift due to leakage during the day.

FLIGHT NUMBER	101 Winsen #120	102 Winsen #121	103 Winsen #122	104 Winsen #123	105 Winsen #124
FLIGHT DATA					
Date Flown	20 January 1953	20 January 1953	21 January 1953	23 January 1953	24 January 1953
Time	0214 CST	1734 CST	0832 CST	0758 CST	0755:43 CST
Balloon Type	No. 73-150-V-266 Winsen Polyethylene 1.5-mil Glass filament tapes Deflator 1½ turns 11,500 feet Duct appendix on top Straight appendix on bottom Standard packing	No. 73-2 X 100-V-260 Winsen Polyethylene 2 X 1-mil Glass filament tapes Deflator 1½ turns Duct appendix on top 13,400 Straight appendix on bottom Standard packed	No. 73-2 X 100-V-258 Winsen Polyethylene 2 X 1-mil Standard Packing #890 tapes Deflator 1½ turns-12,000' Duct Appendix on top Straight appendix on bottom	No. 73-2 X 100-V-269 Winsen Polyethylene 2 X 1-mil #890 tapes Deflator: 1½ turns 15,000 Duct appendix on top Straight appendix on bottom Standard packing	No. 73-150-V-265 Winsen Polyethylene 1.5-mil Glass filament tapes Deflator: 1½ turns 13,800 Duct appendix on top Straight appendix on bottom Standard packing
Date Packed and Packers	7 January 1953 Hanson, Edwards & Winsen packers	6 January 1953 Hanson, Edwards, & Winsen packers	5 January 1953 Edwards, Hanson & Winsen packers	13 January 1953 Hanson, Edwards & Winsen packers	6 January 1953 Hanson, Smith, Edwards, Schmar
Balloon Weight	Net: 162#	Net: 245#	Net: 241#	Net: 238#	Net: 188#
Altitude Theoretical Maximum	91,000 Feet 98,000 Feet	86,000 Feet 77,000 Feet	82,500 Feet 82,000 Feet	81,000 Feet 81,300 Feet	84,000 Feet 82,000 Feet
Purpose	John Naugle's Cosmic Ray Gear	John Naugle's Cosmic Ray Gear	John Linsley's gear	John Winckler's Gear	Anderson-Winckler gear
Duration Planned	8 Hours	24 Hours	10 Hours	8 Hours	10 Hours
Actual Duration	0813 - 1838(Balloon lost) (Last readable signal - 1819)	1735 to 0830 14 Hours 55 Minutes	11 Hours 20 Minutes	8 Hours 30 Minutes (Signal stopped at 1638 CST)	9 Hours 20 Minutes
How Released	Low Altitude Release	Balloon floated to ground	Low Altitude Release	Timers	Timers
GONDOLA DATA					
Gondola No.	151	152	153	154	158
Radio Gear	Xmtr #121 1638 K.C. Antenna Drop #31 - Drops at 4000 Feet Olland Cycle #44	Xmtr #112 1638 K.C. Antenna Drop #32 - 4100 feet Olland Cycle #62	Xmtr #113 1638 K.C. Antenna Drop. #33 - 4050 feet Olland Cycle #63	Xmtr #114 1638 K.C. Antenna Drop #34 - 3900 ft. Olland Cycle #44	Xmtr #118 1638 K.C. Antenna dropper #38 - 3900 ft. Olland Cycle #66
Slow Down	Altitude: Cooks: 56,800 feet #1 Fires: 79,980 feet	Altitude: Cooks: 44,800 feet #2 Fires: 30,000 feet	Altitude: Cooks: 42,000 feet #3 Fires: 29,900 feet	Altitude: Cooks: 52,300 feet #3 Fires: 30,000 feet	Altitude: Cooks: 46,400 #2 Fires: 30,000
Cameras	Down: #43 50 Ft. 1 R.P.M. Plus-X	Down: #17 25 ft 1/5 R.P.M. Plus-X	Down: #39 50 ft. 1 R.P.M. Plus-X	Down: #41 50 ft 1 R.P.M Plus-X	Down: #46 50 ft. 1 R.P.M. Plus-X
Ballast	Dry Ice - 84#	Dry ice - 9#	Dry ice - 75#	Dry ice - 20#	Dry ice - 23#
Flight Control					
Light	None				
Cosmic Ray	Cosmic Ray Plate mover for ... Princeton Counter Spectrum	Cosmic Ray lead block & paraffin additional emulsion stack Princeton counter Rochester plates	Poly-carbon Bx. Rochester plates Princeton counter	Winckler telescope Princeton counter	Cerenkov gondola Naugle's emulsion plates
Temperature Recording					
Miscellaneous					
LAUNCHING	Pyote, Texas				
Inflation Medium	He	He	He	He	He
Displaced Air	465	537	680	660	540
Gross Lift	390#	454#	535#	568#	466#
Gross Load	380#	411#	495#	533#	440#
Free Lift	78#	43#	40#	35#	25#
Percentage Free Lift of Gross Load / Lift / Air Displaced	20.3 18.4 15.3	10.5 9.5 8.0	8.1 7.5 6.45	6.56 6.15 5.3	5.70 5.[illegible] 4.[illegible]
Rate of Rise 1000-300 mb / 300-100 mb / 100mb-ceiling	910 Ft/min 1590	Olland Cycle failure during ascent	760 ft/min 1330	770 ft/min 845 1200	600 1110
Weather Clouds / Ground Wind / Other	None None Temperature 40°F	None 8 M.P.H. 70°F	None Light 30°F	None Light 25°F	None Light 30°
Launching Site	Pyote Air Force Base, Texas	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base
TRACKING					
Radio Frequency	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.
Time in Contact Miscellaneous	10 Hours 6 Minutes	14 Hours 50 Minutes	11 Hours 32 Minutes	8 Hours 40 Minutes	9 Hours 20 Minutes
Airplane Type					
Ships in Contact					

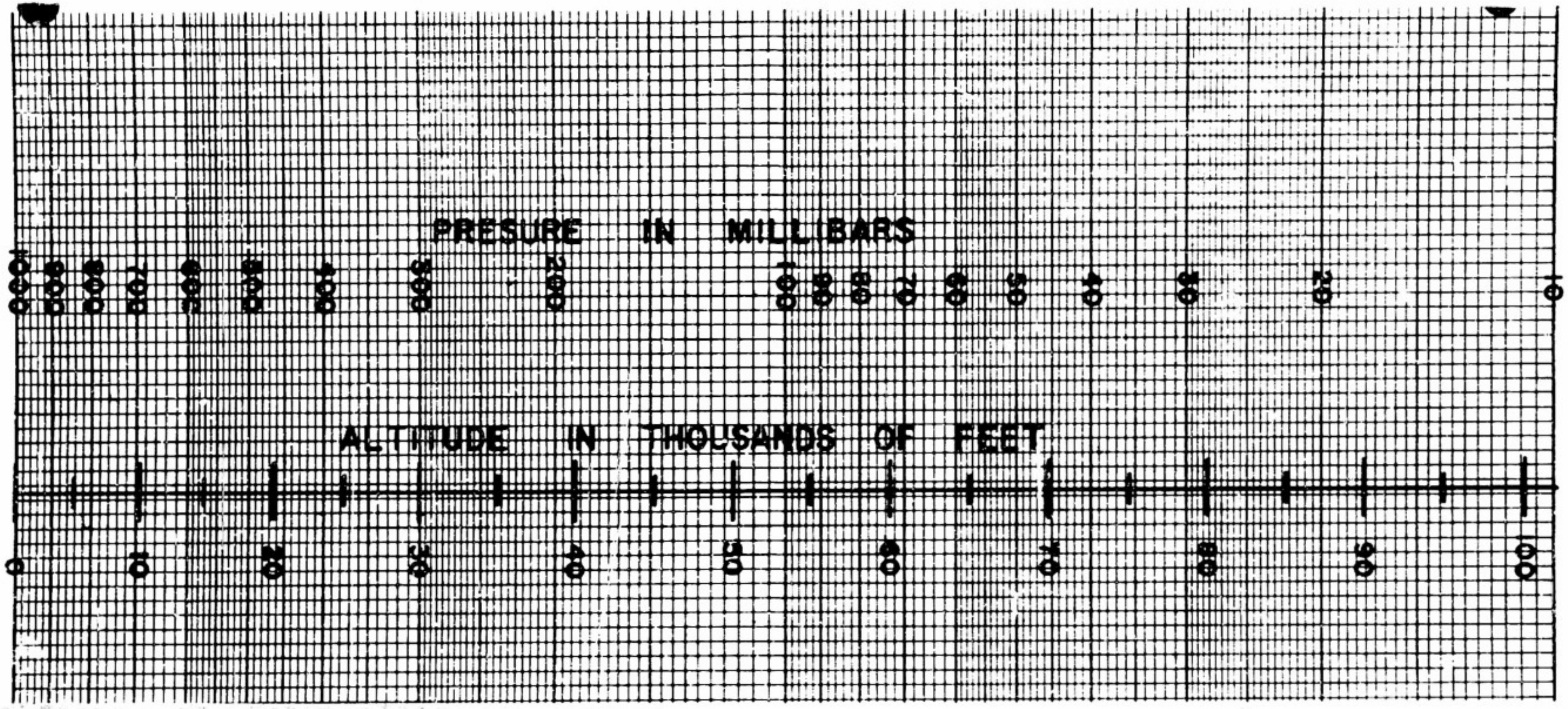
FLIGHT NUMBER	106 Winsen #125	107 Winsen #128	108 Winsen #129	[illegible]
FLIGHT DATA				
Date Flown	26 January 1953	30 January 1953	30 January 1953	1 February 1953
Time	0738:30 CST	0845 CST	0845 CST	[illegible] CST
Balloon Type	No. 73-150-V-262 Winsen Polyethylene 1.5-mil. Standard Packing Glass Filament tapes. Deflator 1½ turns Duct appendix to girdle 12,500 Straight appendix on bottom	No. 73-150-V-263 Winsen Polyethylene - 1.5-mil Glass Filament tapes Duct Appendix to girdle Straight appendix on bottom	No. 73-2 X 100-V-219 Winsen Polyethylene 2 X 1-mil Nylon filament tapes Duct appendix on top Straight appendix on bottom Standard packing 1128 antenna	No. 73-2 X 100-V-[illegible] Winsen Polyethylene 2 X 1-mil Glass filament tapes Deflator: [illegible] Duct appendix to girdle Straight appendix on bottom Standard packing
Date Packed and Packers	12 January 1953 Hanson, Edwards, & Winsen packers	12 January 1953 Hanson, Edwards & Winsen packers	16 December 1952 Hanson, Edwards, Smith, Oehman	13 December 1952 Hanson, Edwards, & Winsen packers
Balloon Weight	Net: 191#	Net: 211#	Net: 255#	Net: 237#
Altitude Theoretical Maximum	86,500 Feet 66,700 Feet	88,000 Feet 88,000	84,000 Feet 83,500 Feet	86,000 Feet 86,900 Feet
Purpose	Cerenkov counter	Naugle gear	Heroite gear	Bohl gear
Duration Planned	10 Hours	9 Hours	7 Hours at altitude	9 Hours
Actual Duration	2 Hours 12 Minutes	8 Hours 51 Minutes	8 Hours 55 Minutes (7 Hours 20 Minutes at altitude)	9 Hours 26 Minutes
How Released	Balloon floated to ground	Timers	Timers	Timers
GONDOLA DATA				
Gondola No.	155	158	156	157
Radio Gear	Xmtr #115 1638 K.C. Antenna Drop #35 Olland Cycle #67	Xmtr #118 1638 K.C. Antenna Drop #38 Olland Cycle #66	Xmtr #116 1638 K.C. Antenna Dropper #36 Olland Cycle #73	Xmtr 1700 K.C. Antenna Dropper #37 Olland Cycle #72
Slow Down	Altitude: Cooks: 42,150 ft. #5 Fires: 30,300 ft.	Altitude: #1	Altitude: Cooks: 53,300 #4 Fires: 30,100	Altitude: Cooks: 59,300 Fires: 30,000
Cameras	Down: #37 50 ft. 1 R.P.M. Plus-X	Down: #46	Down: #45	Down: #38 1 R.P.M.
Ballast	Dry ice - 26#	Dry ice - 29# (in polyethylene box) Dry ice - 27#	Dry ice - 24#	Dry ice - 25#
Flight Control				
Light				
Cosmic Ray	Cerenkov gondola #1 Photo emulsion plates (Naugle)	Chicago and Minnesota N.E. Naugles plate mover University of Chicago Greenhouse Rochester Box	Heroite sphere	Voyvodic's plates (Canadian Nat'l Bohl Gondola Research Council) Single counter
Temperature Recording				
Miscellaneous				
LAUNCHING				
Inflation Medium	He	He	He	He
Displaced Air	578	500	575	542
Gross Lift	450#	430#	497#	469#
Gross Load	408#	375#	452#	431#
Free Lift	40# (23 lbs)	51#	43#	36#
Percentage Free Lift of Gross Load / Lift / Air Displaced	10.3 8.4 7.1	13.5 11.9 9.8	9.5 8.65 7.5	8.35 7.7 6.65
Rate of Rise 1000-300 mb / 300-100 mb / 100mb-ceiling	740 1280	742 ft/min 1380	725 ft/min 805 1050	697 ft/min
Weather Clouds / Ground Wind / Other	None Light 50°	W.S 36°	High-thin Light 40°	None None 55°
Launching Site	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base
TRACKING				
Radio Frequency	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.
Time in Contact Miscellaneous	2 Hours 12 Minutes	8 Hours 51 Minutes	8 Hours 40 Minutes	9 Hours 25 Minutes
Airplane Type				
Ships in Contact				

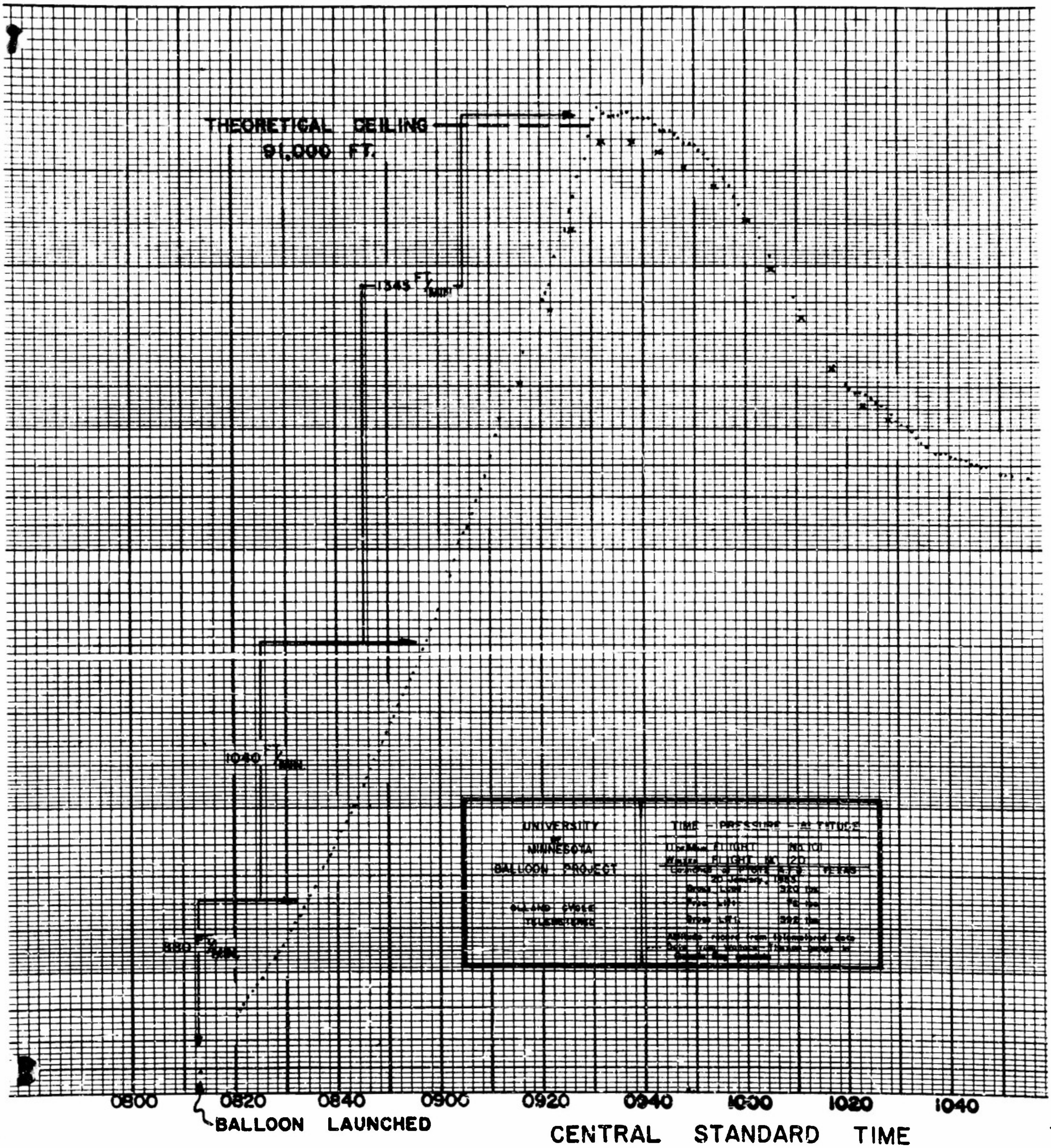
FLIGHT NUMBER	105 Winsen #124	106 Winsen #125	107 Winsen #126	108 Winsen #129	109 Winsen #130	110	111	112	113
FLIGHT DATA									
Date Flown	24 January 1953	26 January 1953	30 January 1953	30 January 1953	1 February 1953	1 February 1953	1 February 1953	3 February 1953	4 February 1953
Time	0755:43 CST	0738:30 CST	0645 CST	0645 CST	0750 CST	0650 CST	1410 CST	0813 CST	0828 CST
Balloon Type	No. 73-150-V-265 Winsen Polyethylene 1.5-mil Glass filament tapes Deflator: 1½ turns 13,800 Dust appendix on top Straight appendix on bottom Standard packing	No. 73-150-V-262 Winsen Polyethylene 1.5-mil.Standard Packing Glass Filament tapes.Deflator 1½ turns Dust appendix to girdle 12,500 Straight appendix on bottom	No. 73-150-V-263 Winsen Polyethylene - 1.5-mil Glass Filament tapes Duct Appendix to girdle Straight appendix on bottom	No. 73-2 X 100-V-249 Winsen Polyethylene 2 X 1-mil Nylon filament tapes Duct appendix on top Straight appendix on bottom Standard packing 112# antenna	No. 73-2 X 100-V-270 Winsen Polyethylene 2 X 1-mil Glass filament tapes Deflator: 1½ turns Duct appendix to girdle 15,700 Straight appendix on bottom Standard packing	No. 73-150-V-264 Winsen Polyethylene 1 X-mil #890 tapes Deflator: 1½ turns Duct appendix to girdle 13,000 Straight appendix on bottom Standard packing	No. 734-AN General Mills, Polyethylene 2 X 1-mil #880 tapes Duct appendix to 12' below girdle Straight appendix on bottom	No. 73-2 X 100-V-259 Winsen Polyethylene 2 X 1-mil #890 tapes Deflator: 1½ turns Dust appendix to girdle 13,000 Straight appendix on bottom Standard packing	No. 73-2 X 100-V-247 Winsen Polyethylene 2 X 1-mil Nylon on girdle #880 tapes Standard packing Dust appendix to 6' above girdle Deflator: 1½ turns - 11,500
Date Packed and Packers	6 January 1953 Hanson, Smith, Edwards, Gohman	12 January 1953 Hanson, Edwards, & Winsen packers	12 January 1953 Hanson, Edwards & Winsen packers	16 December 1952 Hanson, Edwards, Smith, Gohman	13 December 1952 Hanson, Edwards, & Winsen packers	9 January 1953 Hanson & Winsen packers	23 January 1953 Edwards, Lahti, Hoberg, Gohman	8 January 1953 Hanson, Edwards & Winsen packers	12 December 1952 Hanson, Smith, Edwards
Balloon Weight	Net: 188#	Net: 191#	Net: 211#	Net: 255#	Net: 237#	Net: 190#	256#	Net: 239#	
Altitude Theoretical Maximum	84,000 Feet 82,000 Feet	86,500 Feet 65,700 Feet	88,000 Feet 88,000	84,000 Feet 83,500 Feet	86,000 Feet 86,900 Feet	82,000 Feet 82,000 Feet	84,000 Feet 79,000	84,300 feet 82,000 feet	81,500 Feet 78,000 Feet
Purpose	Anderson-Winckler gear	Cerenkov counter	Naugle gear	Borowitz gear	Bohl gear	McDonald gear	Linsley gear	Winckler gear	McDonald gear
Duration Planned	10 Hours	10 Hours	9 Hours	7 Hours at altitude	9 Hours	9 Hours	30 Hours	8 Hours	
Actual Duration	9 Hours 20 Minutes	2 Hours 12 Minutes	8 Hours 51 Minutes	8 Hours 55 Minutes (7 Hours 20 Minutes at altitude)	9 Hours 26 Minutes	9 Hours 20 Minutes	6 Hours 44 Minutes	8 Hours 53 Minutes	
How Released	Timers	Balloon floated to ground	Timers	Timers	Timers	Timers	Balloon ruptured	Timers	
GONDOLA DATA									
Gondola No.	15[illegible]	155	158	156	157	159	152	No gondola	159
Radio Gear	Xmtr #118 1638 K.C. Antenna dropper #38 - 3900 ft. Olland Cycle #66	Xmtr #115 1638 K.C. Antenna Drop #35 Olland Cycle #67	Xmtr #118 1638 K.C. Antenna Drop #38 Olland Cycle #66	Xmtr #116 1638 K.C. Antenna Dropper #36 Olland Cycle #73	Xmtr 1700 K.C. Antenna Dropper #37 Olland Cycle #72	Xmtr #119 1638 K.C. Antenna dropper #39 Olland Cycle #74	Xmtr #122 1638 K.C. Antenna dropper #33 - 4050 ft. Olland Cycle #72	Olland Cycle #77C	Xmtr #119 1638 K.C. Olland Cycle #75 Antenna Dropper #39
Blow Down	Altitude: #2 Cocks: 46,400 Fires: 30,000	Altitude: #5 Cocks: 42,150 ft. Fires: 30,300 ft.	Altitude: #1	Altitude: #4 Cocks: 53,300 Fires: 30,100	Altitude: Cocks: 52,300 Fires: 30,000	Altitude: #8 Cocks: 46,300 Fires: 29,800	Altitude: #8 Cocks: 46,300 Fires: 25,800	Altitude #1	Altitude: #2 Cocks: 46,300 feet Fires: 29,500 feet
Cameras	Down: #46 50 ft. 1 R.P.M. Plus-X	Down: #37 50 ft. 1 R.P.M. Plus-X	Down: #46	Down: #45	Down: #38 1 R.P.M.	Down #40	Down: #17 1/5 R.P.M. 25 feet Plus-X	Down: #37	Down: #46
Ballast	Dry ice - 23#	Dry ice - 26#	Dry ice - 29# (in polyethylene box) Dry ice - 27#	Dry ice - 24#	Dry ice - 15#	Dry ice - 12 #	Ballast drop - Fires 39,000 feet		
Flight control									
Light									
Cosmic Ray	Cerenkov gondola Naugle's emulsion plates	Cerenkov gondola #1 Photo emulsion plates (Naugle)	Chicago and Minnesota N.H. Naugles plate rover University of Chicago Greenhouse Rochester Box	Borowitz sphere	Voyvodick's plates (Canadian Nat'l Research Council) Bohl Gondola Single counter	McDonald cloud chamber	Linsley's gondola	Winckler's Cerenkov gondola	McDonald's sphere
Temperature Recording									
Miscellaneous									
LAUNCHING									
Inflation Medium	He	He	He	He	He	He	He	He	He
Displaced Air	540	578	500	575	542	562	548	567	625
Gross Lift	4660#	4508#	4309#	4779#	4678#	4058#	4738#	4899#	5398#
Gross load	4400#	4088#	3799#	4549#	4318#	4378#	4388#	4439#	5108#
Free Lift	250#	420# (±3 lbs)	510#	430#	360#	480#	350#	460#	290#
Percentage Free Lift of Gross Load / Lift / Air Displaced	5.70 5.4 4.6	10.3 9.4 7.1	13.5 11.9 9.8	9.5 8.65 7.5	8.35 7.7 6.65	11.0 9.9 8.55	8.0 7.4 6.38	10.4 9.4 8.1	5.5 5.2 4.5
Rate of Rise 1000-300 mb / 300-100 mb / 100 mb-ceiling	600 1110	740 1290	760 ft/min 1380	725 Ft/min 805 1050	697 ft/min				
Weather Clouds / Ground Wind	None Light 30°	None Light 50°	W-5 36°	High-thin Light 40°	None None 55°	None None 55°	60° F	Clear 40° F	Overcast - 20,000 feet None 50° F
Launching Site	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base
TRACKING									
Radio Frequency	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.
Time in Contact	9 Hours 20 Minutes	2 Hours 12 Minutes	8 Hours 51 Minutes	8 Hours 40 Minutes	9 Hours 25 Minutes	9 Hours 20 Minutes	6 Hours 44 Minutes	8 Hours 53 Minutes	4 Hours 46 Minutes
Miscellaneous									
Airplane Type									
Hours in Contact									
Truck When dispatched Hours in Contact									

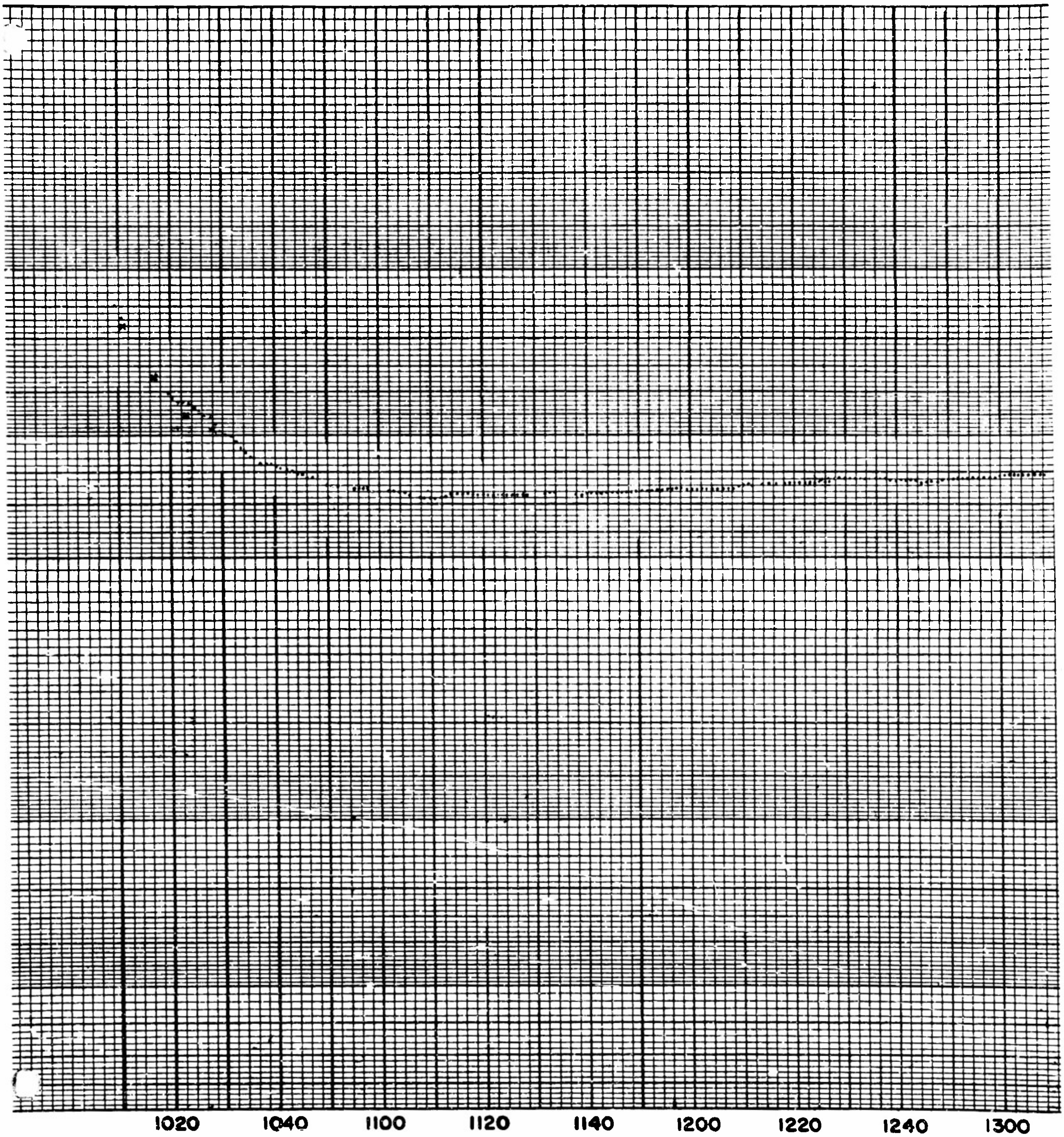
[illegible]	1570	[illegible] cycle failure during ascent		1800	1110	1980	1300	805 1050		
Weather Clouds Ground Wind Other	None Temperature 40°F	None 8 M.P.H. 70° F	None light 30°F	None Light 25° F	None Light 30°	None Light 50°	N-5 30°	High-thin Light 30°	[illegible]	
Launching Site	Pyote Air Force Base, Texas	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base
TRACKING										
Radio Frequency	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.
Time in Contact Miscellaneous	10 Hours 6 Minutes	14 Hours 50 Minutes	11 Hours 32 Minutes	8 Hours 40 Minutes	9 Hours 20 Minutes	2 Hours 12 Minutes	8 Hours 51 Minutes	8 Hours 40 Minutes	9 Hours 25 Minutes	9 Hours 20 Minutes
Airplane Type Hours in Contact										
Truck When dispatched										
Theodolite Stations on Hours in contact	Pyote Air Force Base 0905 to 1830 9 Hours 25 Minutes		Pyote Air Force Base 0925 to 1610 6 Hours 45 Minutes	Pyote Air Force Base 0925 to 1420 4 Hours 55 Minutes	Pyote Air Force Base 0830 to 1315 4 Hours 45 Minutes	Pyote Air Force Base 0800 to 0915 1 Hour 15 Minutes		Pyote Air Force Base 1432 to 1900 4 Hours 28 Minutes		Pyote Air Force Base 0910 to 1730 8 Hours 20 Minutes
RECOVERY IMPACT										
Estimate Before Flight										
Actual Impact Balloon	Found floating near Port Arthur, Texas	S. Peacock, Texas	10-20 miles north of Gale, Texas							
Load	On ground near Waco, Texas	Same	East of Altus, Oklahoma	30 Miles SE Abilene, Texas	7 Miles N of Glen Rose, Texas	5 Miles north of Big Lake, Texas	Brownwood, Texas	San Saba, Texas	30 Miles S Sweetwater, Texas	20 Miles SW Abilene
Dates and Time Balloon		0830 - 21 January								
Load	1820 - 20 January 1953	Same	2010 - 21 January 1953	1655 - 23 January 1953	1740 - 24 January 1953	28 January	1758 - 30 January 1953	1800 - 30 January 1953	1745 - 1 February 1953	1820 - 1 February
Notified of Position How When	Telephone 27 May 1953 - 1015 (Load)	Telephone - Via Minneapolis 1300 - 21 January 1953	Telephone via Minneapolis 1500 - 21 January 1953 1540 - 22 January 1953			Air Search				
Recovered by Balloon Load						San Angelo area Air Force				
Gear Recovered	Complete Assemblage	Complete exceptions: additional stack of emulsion plates missing.	Complete assemblage	Nothing recovered	Complete Assemblage	Complete Assemblage	Complete Assemblage	Complete Assemblage	Complete Assemblage.	Complete Asse[illegible]
Miscellaneous										
CAA CONTACTS	C A A CONTACTS BY WINZEN RESEARCH, INC.									
Preflight									0710 - E.P. Way to J.A.	0710 - E. Way
Takeoff									0750 - J.R. Winkler to J.A.	0856 - J.R. Wink[illegible]
In Flight										
Termination									1830 - Way to E.S.	1830 - E. Way
GONDOLA RECORDS										
Up Camera										
Down Camera	584 Frames	29 Frames	505 Frames	463 Frames	514 Frames	466 Frames	535 Frames	560 Frames	529 Frames	616 Frames
Other										
ENT [illegible] NOTIFICATIONS	E N T CONTACTS BY WINZEN RESEARCH, INC.									
LAUNCH										
IN FLIGHT										
TERMINATION										
Photographic coverage, of launch, etc.	W I N Z E N RESEARCH, INC. - MOVIES & STILLS									35 MM
16 mm motion picture										
Stills										
Other										
PRINCIPLE CHARACTERISTICS OF FLIGHT	Balloon was weighed off too light. Rate increased from 850 to over 1800 ft/min. Believe balloon ruptured at ceiling, descended and took air. It leveled at 60,000 feet and drifted out of telemetering range. It descended at Port Arthur, after dropping the load on low altitude release at Waco, Texas. N.G. for scientific data.	Balloon was to have sunset on ascent and level at ceiling during night and next day. Apparently free lift was exactly equal to sunset effect and balloon levelled below ceiling at 47 mb. It descended at sunrise, probably indicating a leak developed during night or when sun hit tapes in morning. OK for scientific data.	Excellent flight. Balloon began descent at earth sunset time and accelerated at sunset. Change of rate at tropopause. Release timer failed but dust brought the balloon down after sunset.	Excellent flight. Cause of initial drop unknown. Levelling assumed due to dry ice evaporation.	Excellent flight. Pre-sunset effect noticeable but small.	Balloon failure at 67,000 feet for unknown reasons.	Excellent, uneventful.	Excellent Skyhook flight	Reached theoretical ceiling. Cause of descent at 1200 unknown. Girdle catcher left off. Load snapped off chute upon opening at 30,000 on low blow.	Excellent

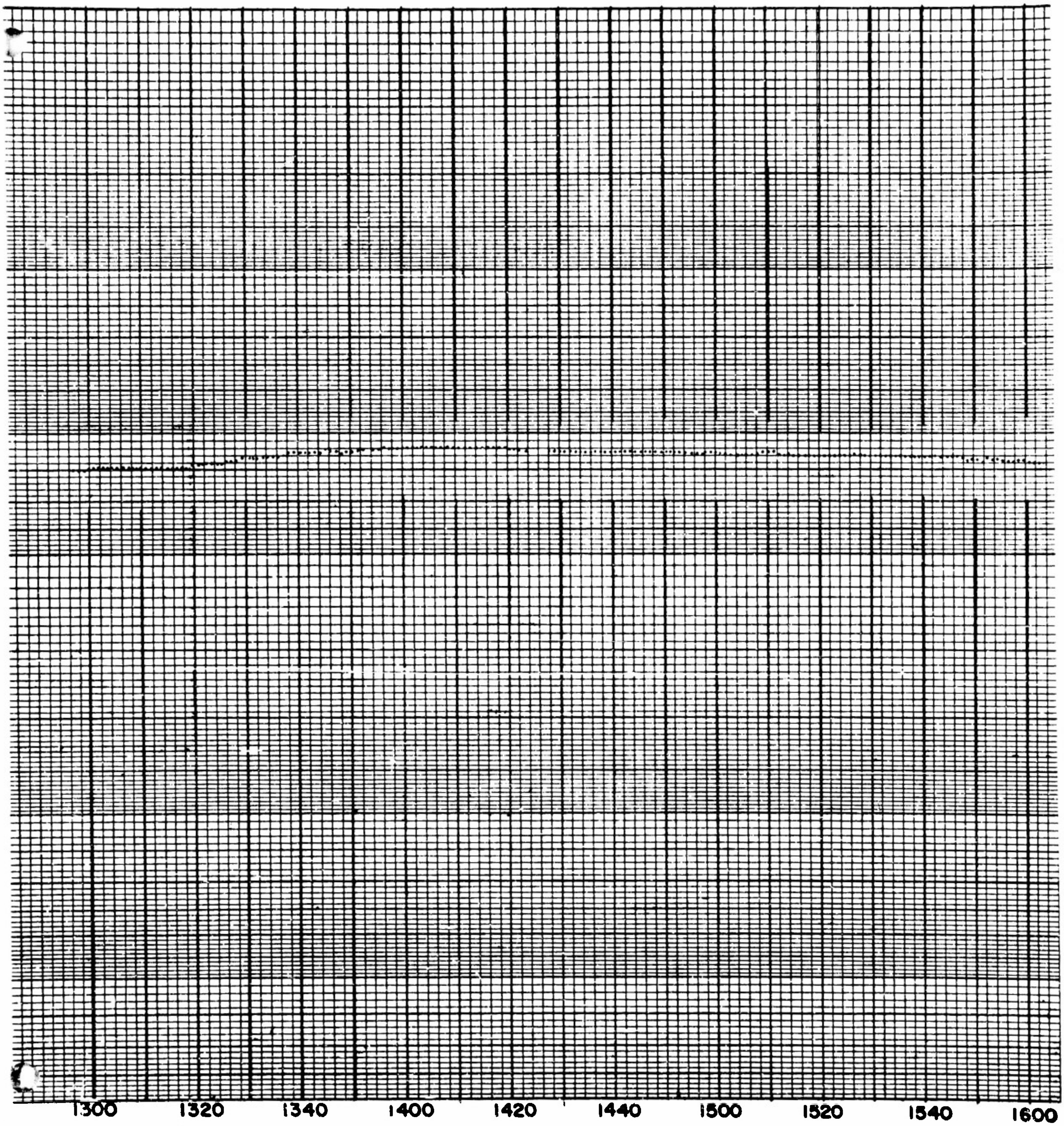
WEATHER Clouds Ground Wind		Light 30°	[illegible] 50°	W-5 36°	[illegible] 40°	[illegible] 55°	None 55°	60° F	Clear 40° F	None 50° F
Launching Site	[illegible]	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base	Pyote Air Force Base
TRACKING										
Radio Frequency		1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.	1638 K.C.
Time in Contact		9 Hours 20 Minutes	2 Hours 12 Minutes	8 Hours 51 Minutes	8 Hours 40 Minutes	9 Hours 25 Minutes	9 Hours 20 Minutes	6 Hours 44 Minutes	8 Hours 53 Minutes	4 Hours 46 Minutes
Miscellaneous										
Airplane Type Hours in Contact										
Truck When dispatched Hours in Contact										
Theodolite Stations on Hours in Contact	[illegible]	Pyote Air Force Base 0830 to 1315 4 Hours 45 Minutes	Pyote Air Force Base 0800 to 0915 1 Hour 15 Minutes		Pyote Air Force Base 1432 to 1900 4 Hours 28 Minutes		Pyote Air Force Base 0910 to 1730 8 Hours 20 Minutes	Pyote Air Force Base 1432 - 1900 4 Hours 28 Minutes	Pyote Air Force Base 0830 to 1800 (EST) 9 Hours 30 Minutes	Pyote Air Force Base 0840 to 0908 28 Minutes
RECOVERY IMPACT										
Estimate Before Flight										
Actual Impact Balloon Load	[illegible], Texas	7 Miles N of Glen Rose, Texas	5 Miles north of Big Lake, Texas	Brownwood, Texas	San Saba, Texas	30 Miles S Sweetwater, Texas	70 Miles SW Abilene, Texas	30 miles W San Angelo, Texas	Nolan, Texas	Menard, Texas
Dates and Time Balloon										
Load	[illegible] January 1953	1740 - 24 January 1953	28 January	1758 - 30 January 1953	1800 - 30 January 1953	1745 - 1 February 1953	1820 - 1 February 1953	2114 - 1 February 1953	1729 - 3 February 1953	
Notified of Position How When			Air Search							Telephone via Minneapolis 1 March 1953
Recovered by Balloon Load			San Angelo area Air Force							
Gear Recovered	Recovered	Complete Assemblage	Complete Assemblage	Complete Assemblage	Complete Assemblage	Complete Assemblage	Complete Assemblage	Cosmic ray gear Gondola	Complete Assemblage	Gondola and Cosmic Ray Sphere
Miscellaneous										
CAA CONTACTS										
Preflight	WINZEN RESEARCH, INC.					0710 - E.P. May to J.A.	0710 - E. May to J.A.	1313 - J.R. Winckler to C.O. (El Paso, Texas)	0730 - E. May to O.B.	
Takeoff						0750 - J.R. Winckler to J.A.	0856 - J.R. Winckler to J.A.	1416 - Winckler to C.O.	0813 - A.A. to O.B.	
In Flight								1830 - May to A.S.	1406 - A.A. to C.L.	
Termination						1830 - May to R.S.	1830 - E. May to A.S.	2135 - E.P. May to A.S.	1730 - E. May to C.L.	
GONDOLA RECORDS										
Up Camera	[illegible] Frames	514 Frames	486 Frames	535 Frames	560 Frames	529 Frames	616 Frames	80 Frames	463 Frames	388 Frames
Down Camera										
Other										
[illegible] WEATHER CENTRAL NOTIFICATIONS										
LAUNCH	WINZEN RESEARCH, INC.									
INFLIGHT										
TERMINATION										
Photographic Coverage Of launch, etc.										
16 mm Motion Picture	MOVIES & STILLS					35 MM UNIVERSITY OF MINNESOTA				
Rolliflex										
Other										
PRINCIPLE CHARACTERISTICS OF FLIGHT	[illegible] Gusts of [illegible]. Levelling [illegible] ice evaporation.	Excellent flight. Pre-sunset effect noticeable but small.	Balloon failure at 67,000 feet for unknown reasons.	Excellent. uneventful.	Excellent Skyhook flight	Reached theoretical ceiling. Cause of descent at 1200 unknown. Girdle catcher left off. Load snapped off chute upon opening at 30,000 on low blow.	Excellent SKYHOOK	Sunset rate 520 ft/min above tropopause. Ballast drop of 152 lbs gave up velocity of 1300 ft/min. Limit due to aerodynamic drag? Tropopause effect = $\frac{760}{520}$ = 1.46	Excellent SKYHOOK	Good flight

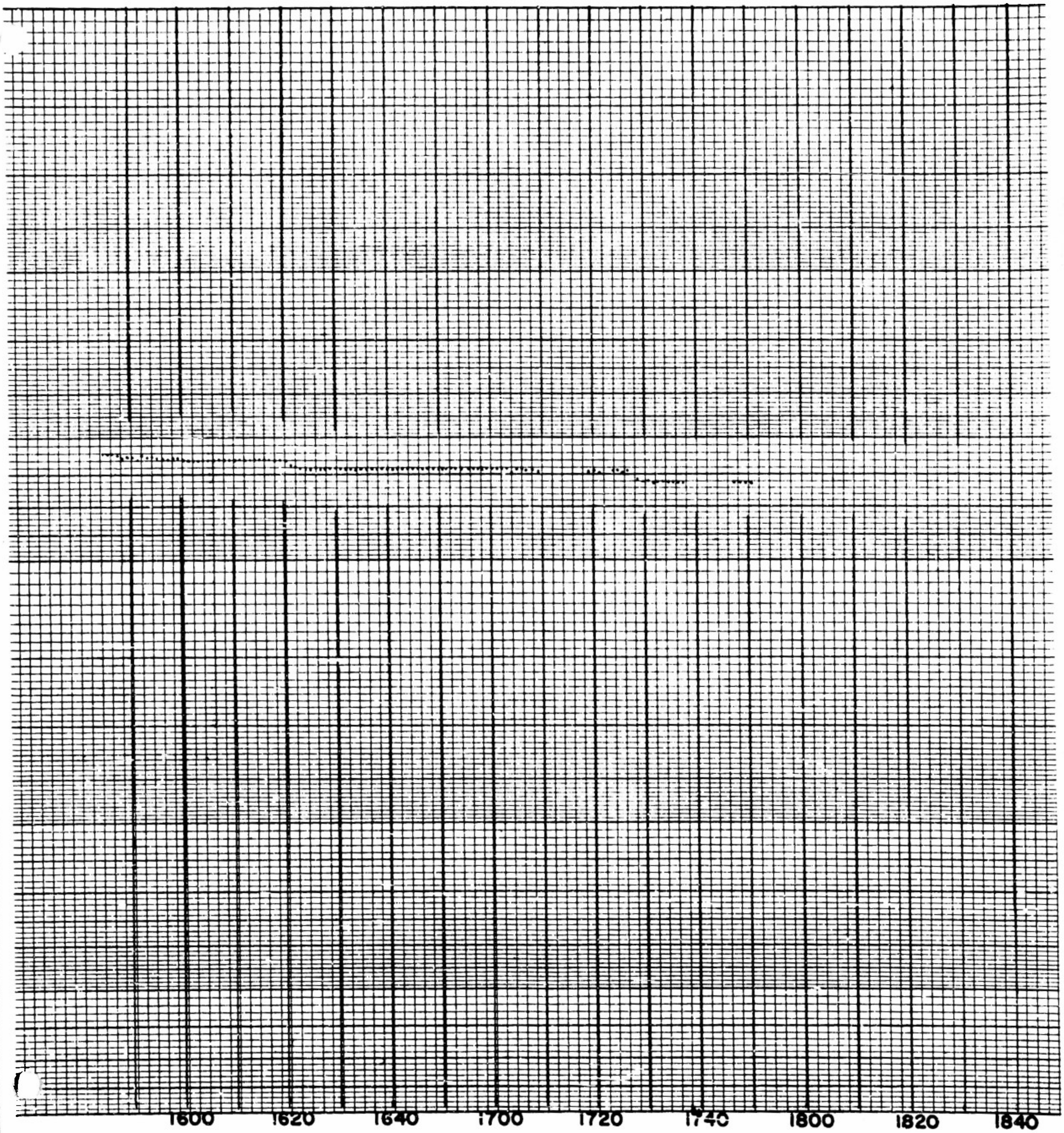
4

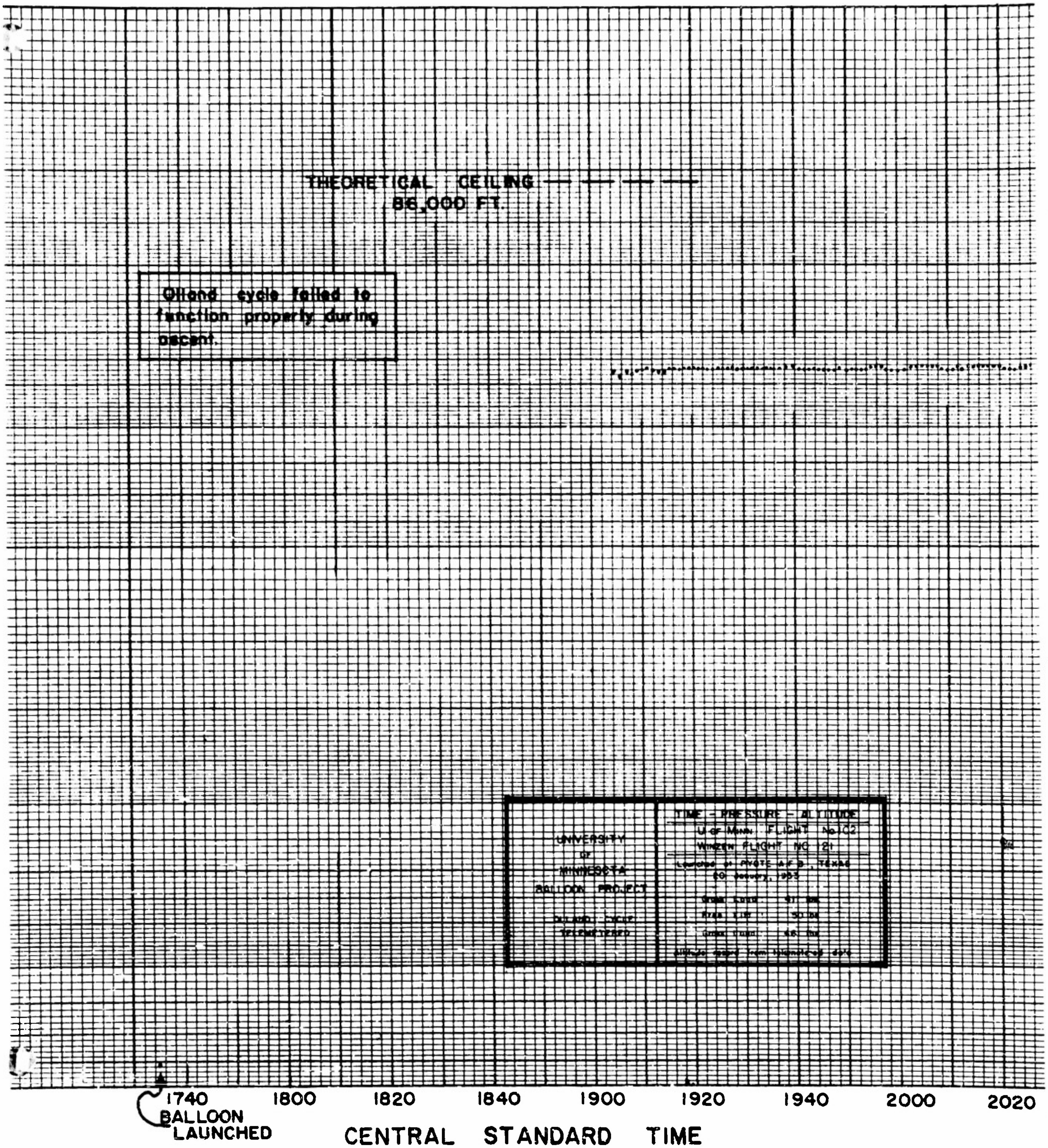

PRESURE IN MILLIBARS
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
ALTITUDE IN THOUSANDS OF FEET
0
10
20
30
40
50
60
70
80
90
100

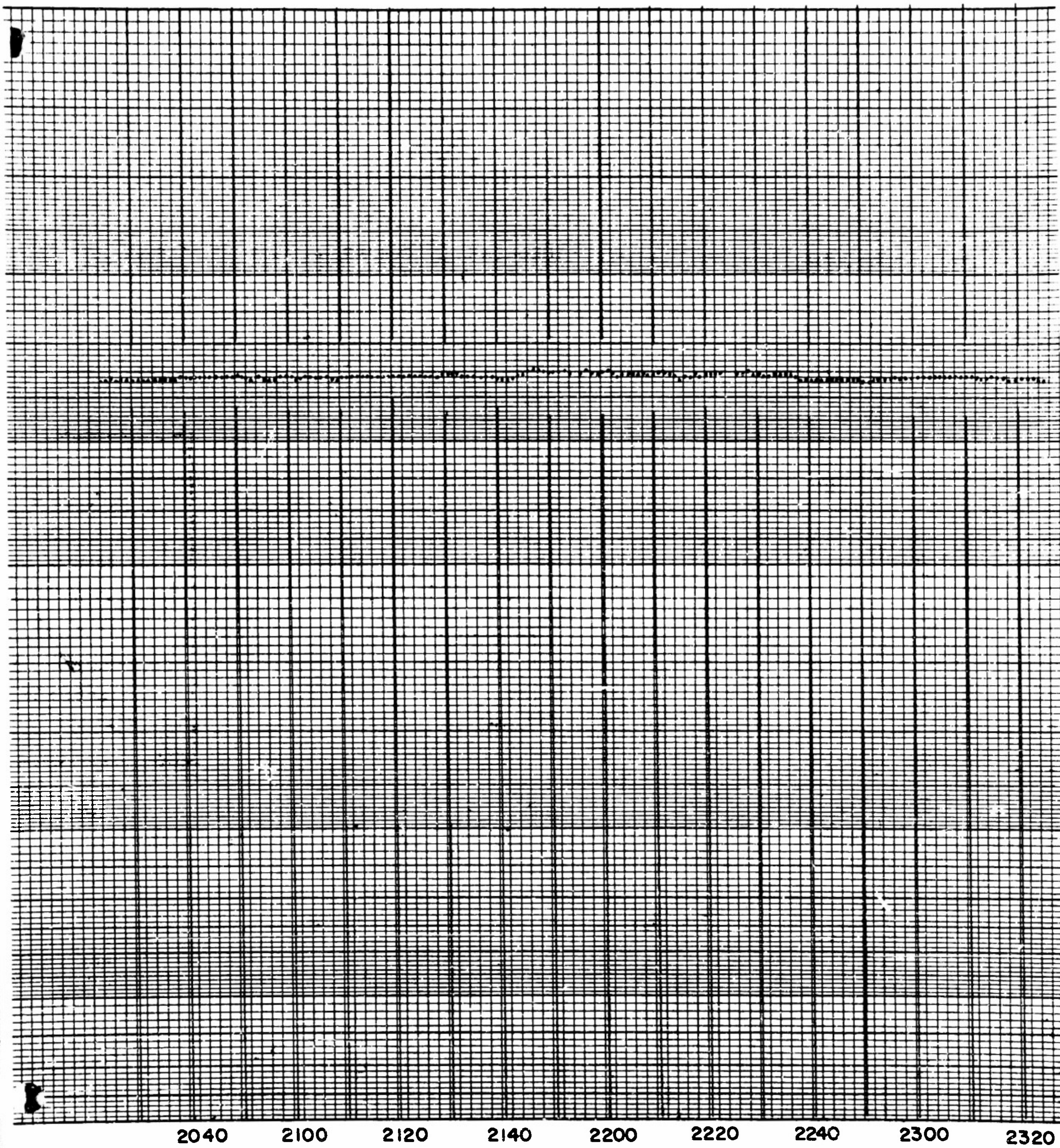

THEORETICAL CEILING
91,000 FT.
1345 FT/MIN
1040 FT/MIN
880 FT/MIN
UNIVERSITY
OF
MINNESOTA
BALLOON PROJECT
TIME - PRESSURE - ALTITUDE
FLIGHT NO 20
0800
0820
0840
0900
0920
0940
1000
1020
1040
BALLOON LAUNCHED
CENTRAL STANDARD TIME

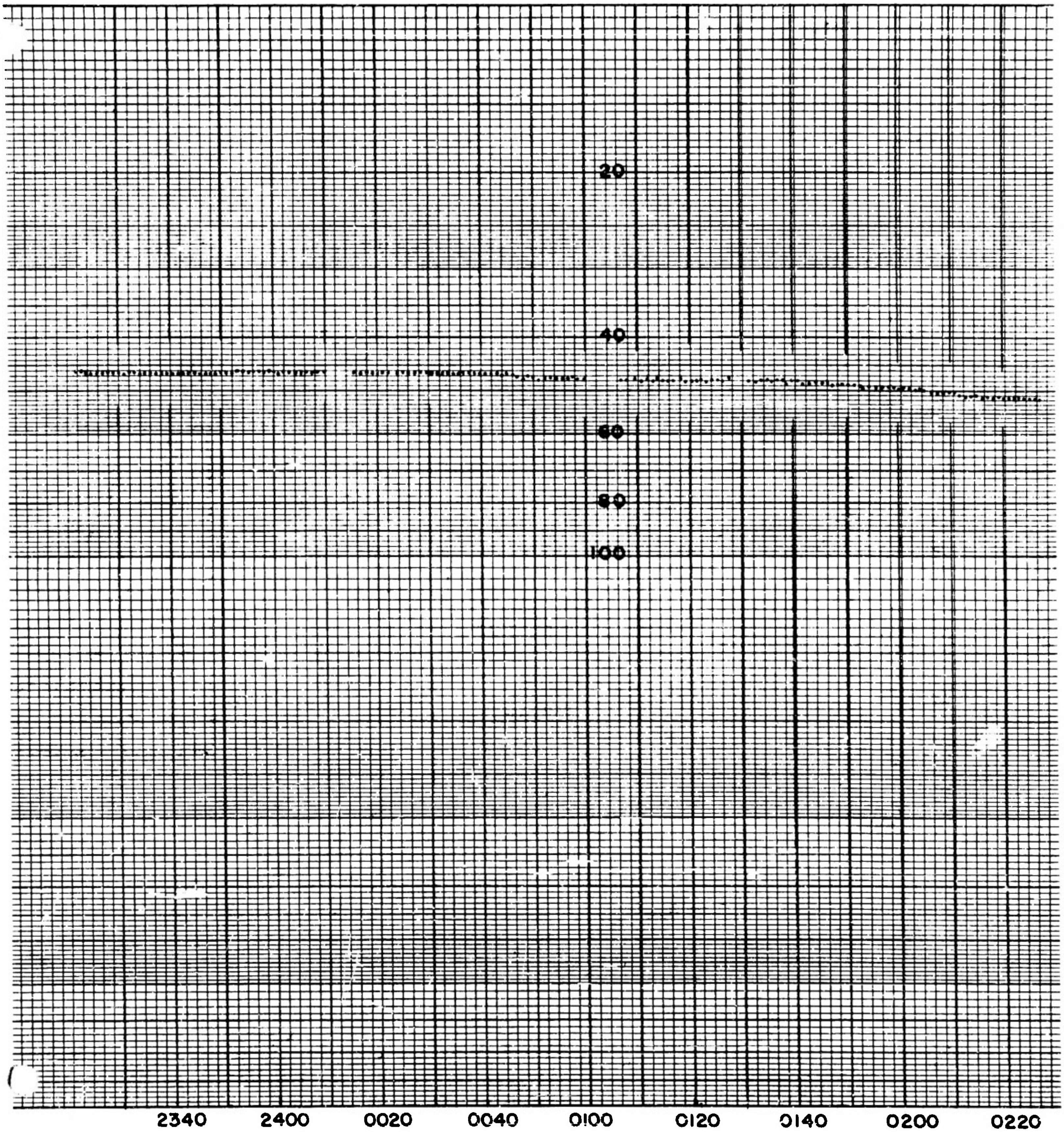

1020
1040
1100
1120
1140
1200
1220
1240
1300

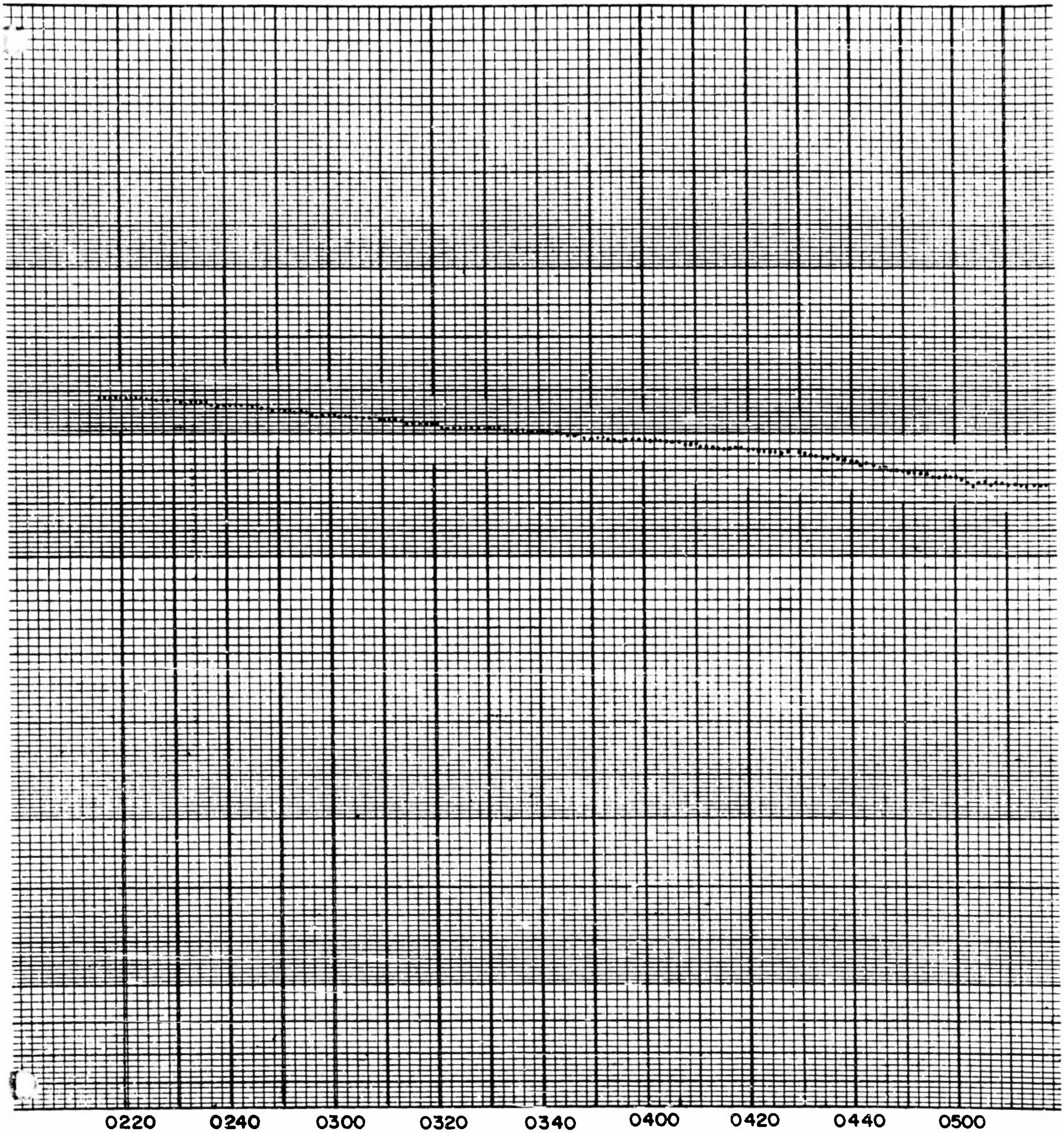

1300
1320
1340
1400
1420
1440
1500
1520
1540
1600

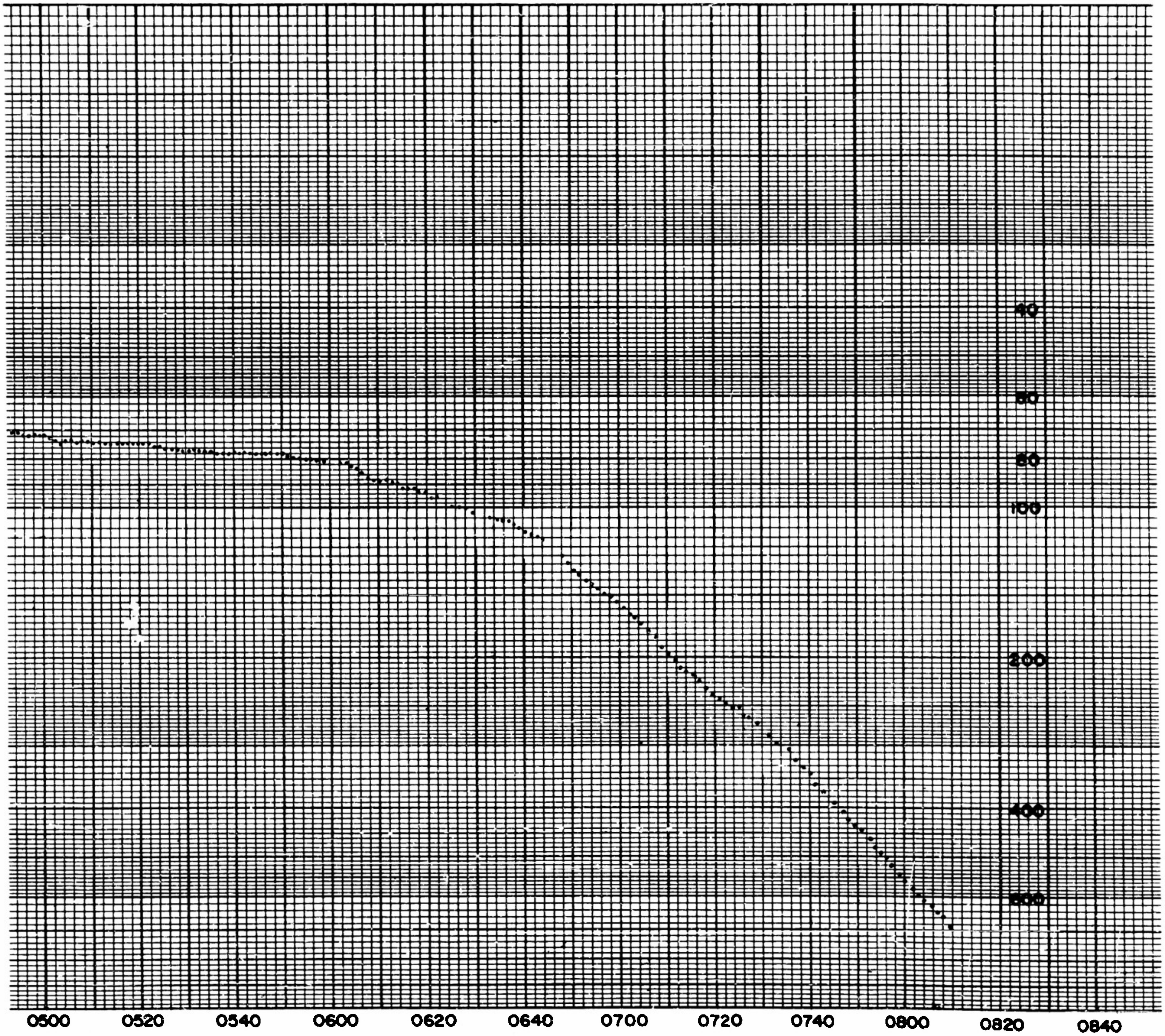

1600
1620
1640
1700
1720
1740
1800
1820
1840

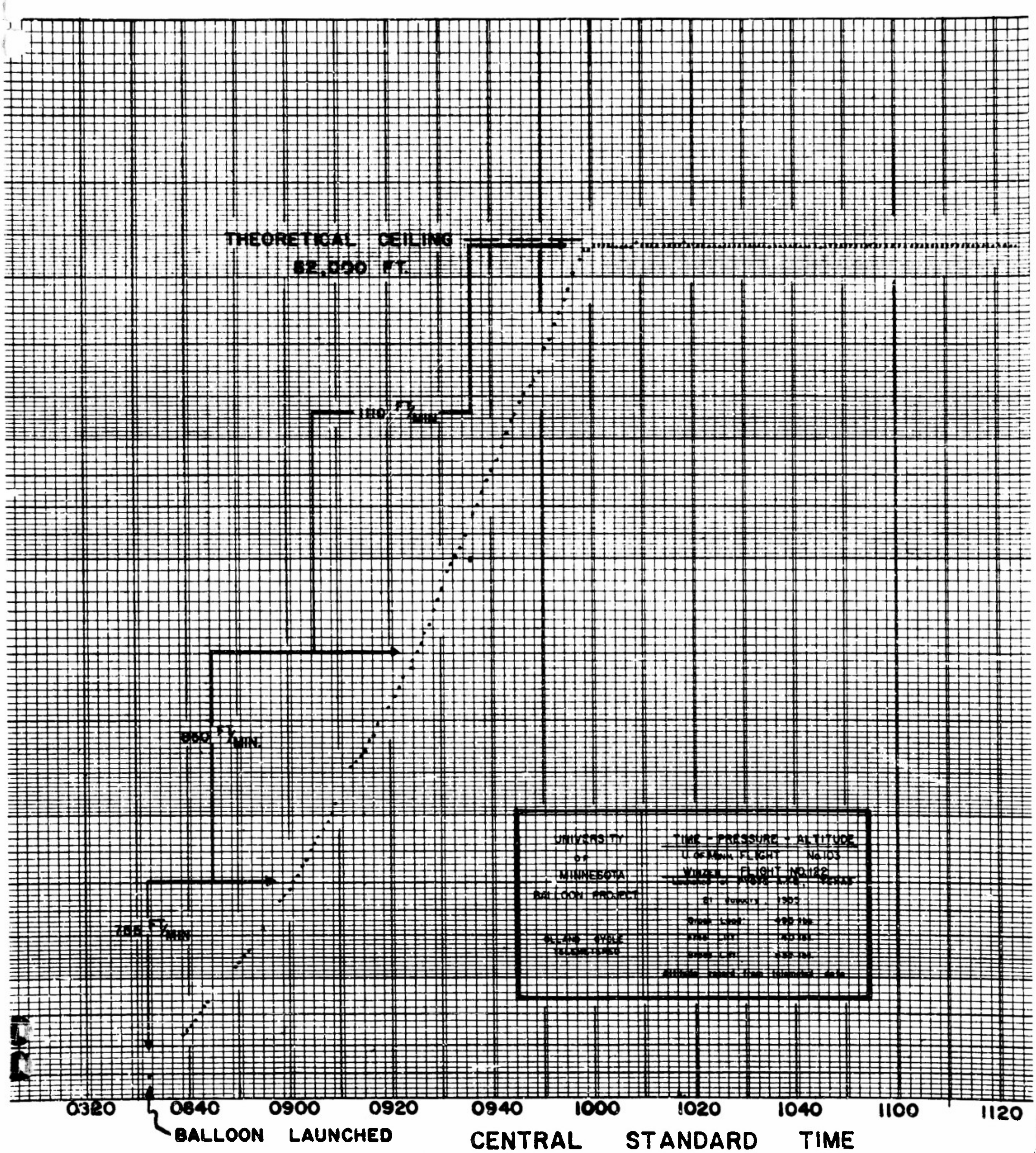

THEORETICAL CEILING
86,000 FT.
Olland cycle failed to function properly during ascent.
TIME - PRESSURE - ALTITUDE
U of Minn FLIGHT No 102
WINZEN FLIGHT NO 121
UNIVERSITY
OF
MINNESOTA
BALLOON PROJECT
1740
1800
1820
1840
1900
1920
1940
2000
2020
BALLOON
LAUNCHED
CENTRAL STANDARD TIME

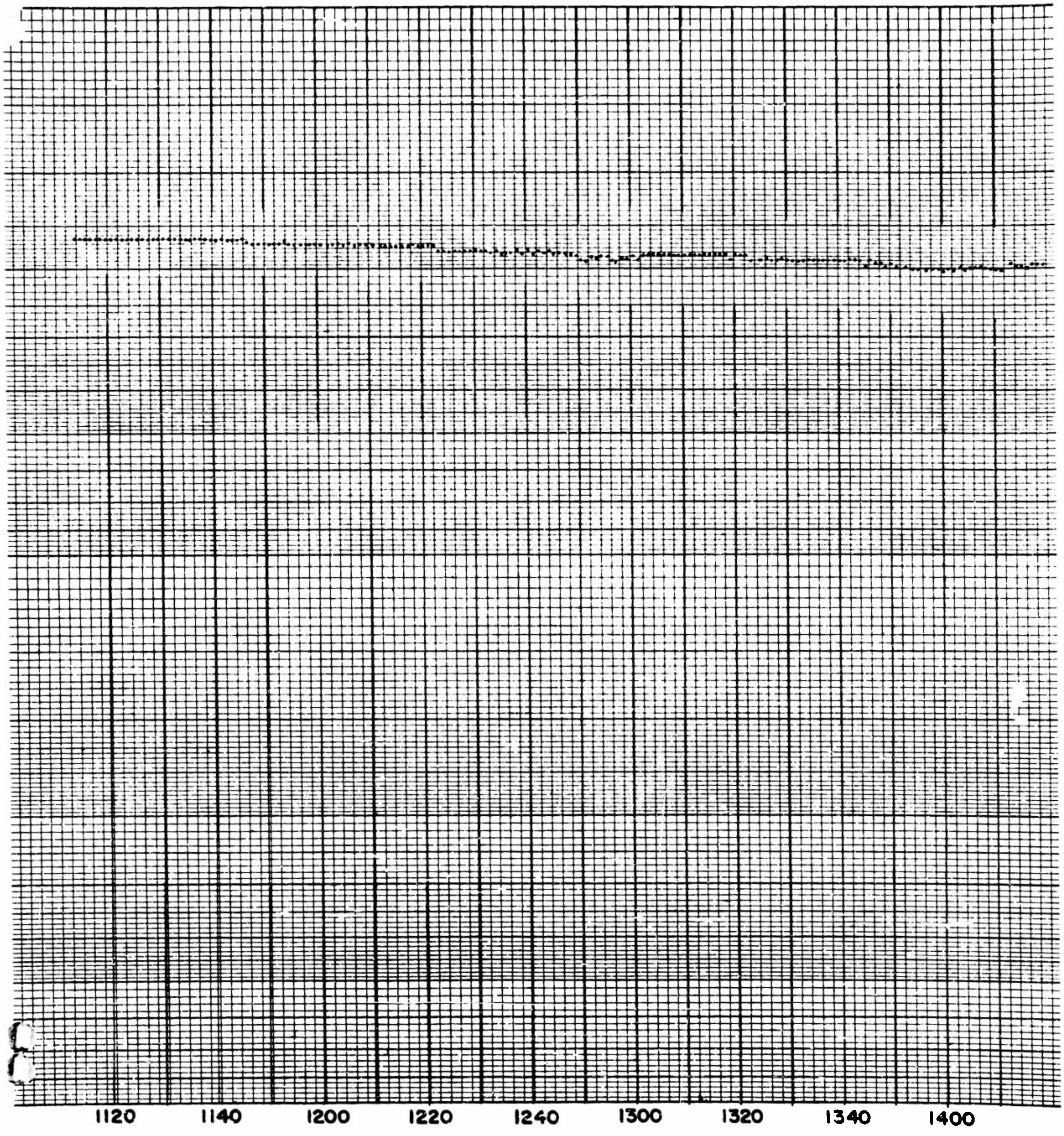

2040
2100
2120
2140
2200
2220
2240
2300
2320

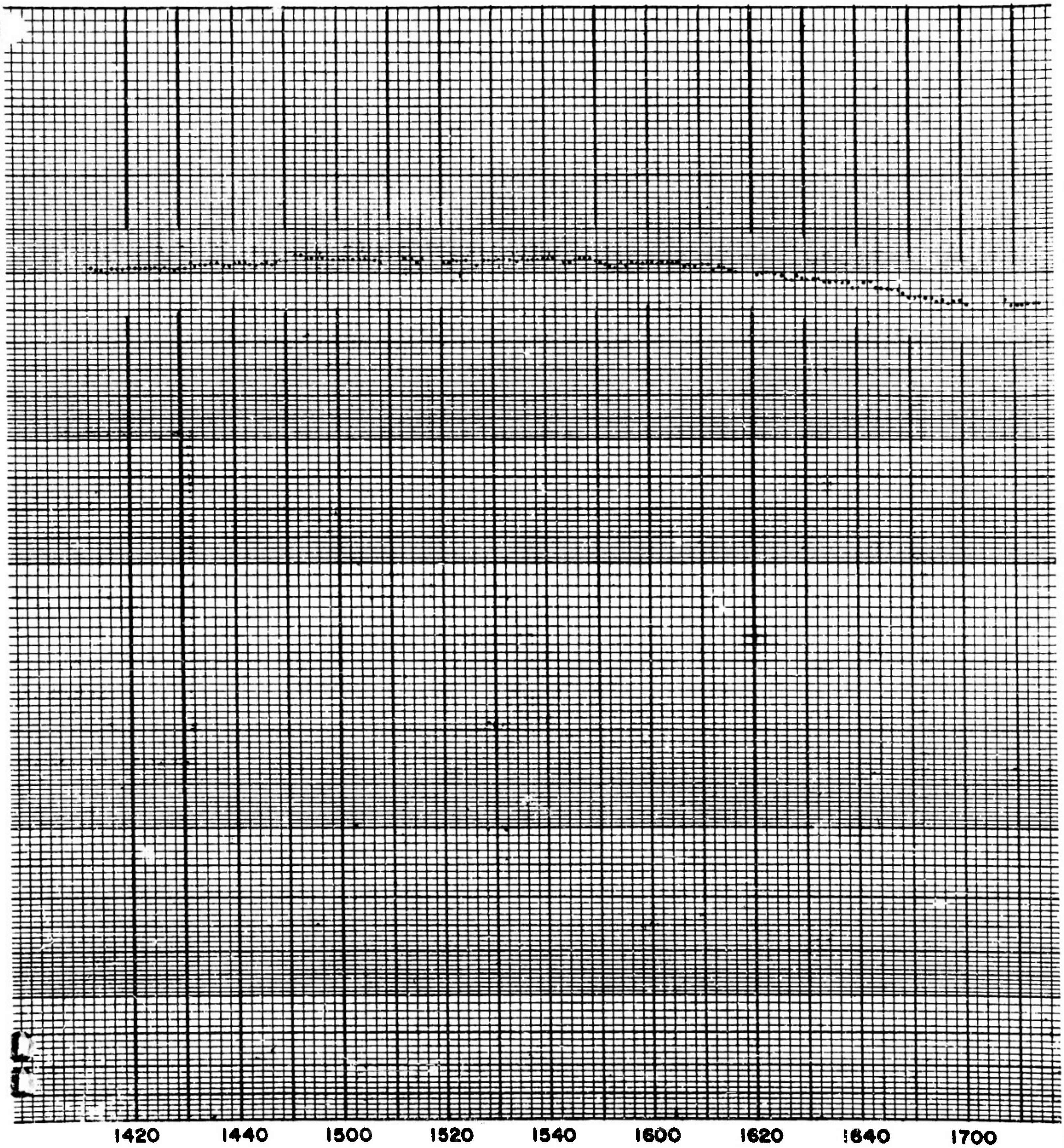

20
40
60
80
100
2340
2400
0020
0040
0100
0120
0140
0200
0220

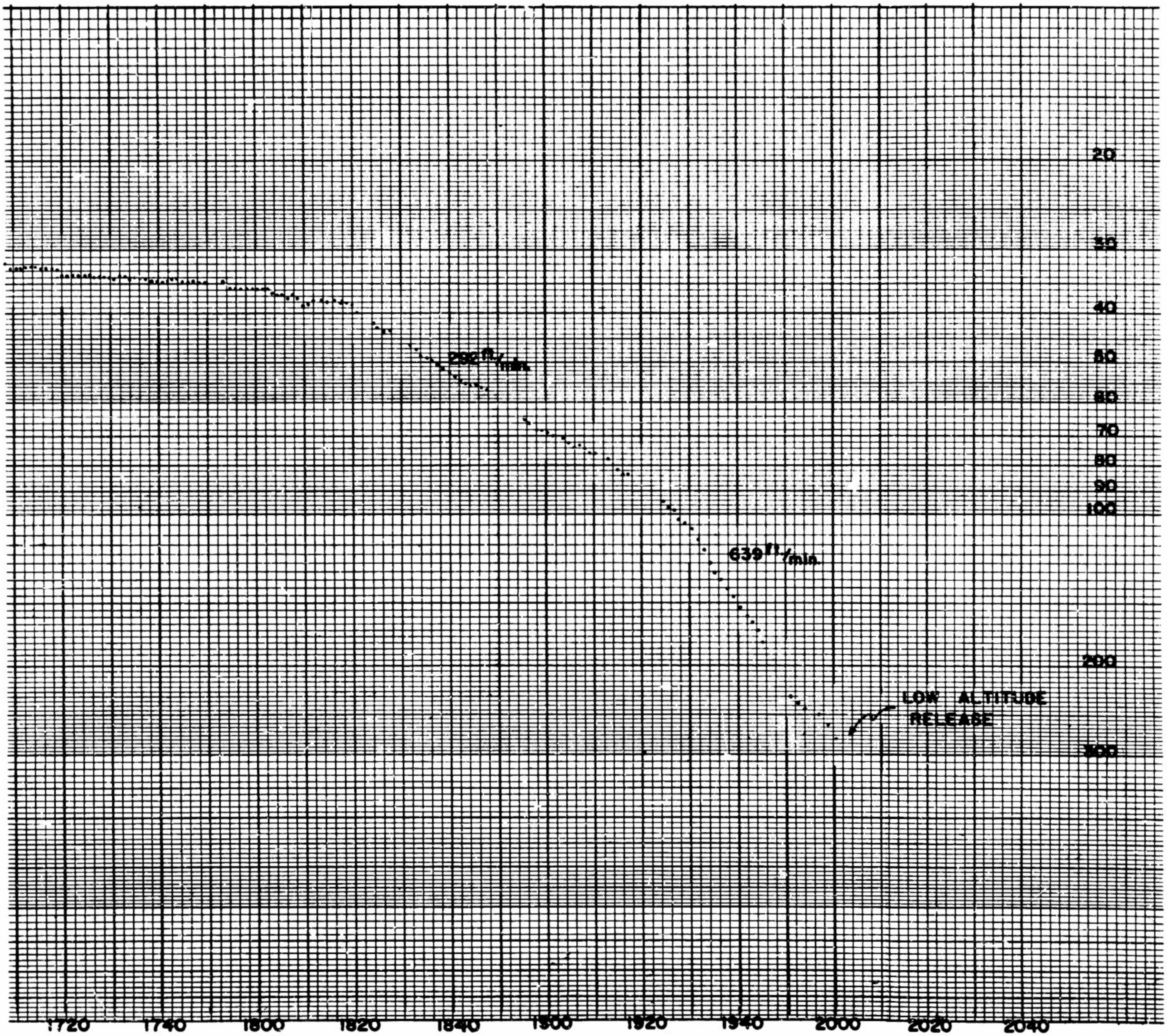

0220
0240
0300
0320
0340
0400
0420
0440
0500

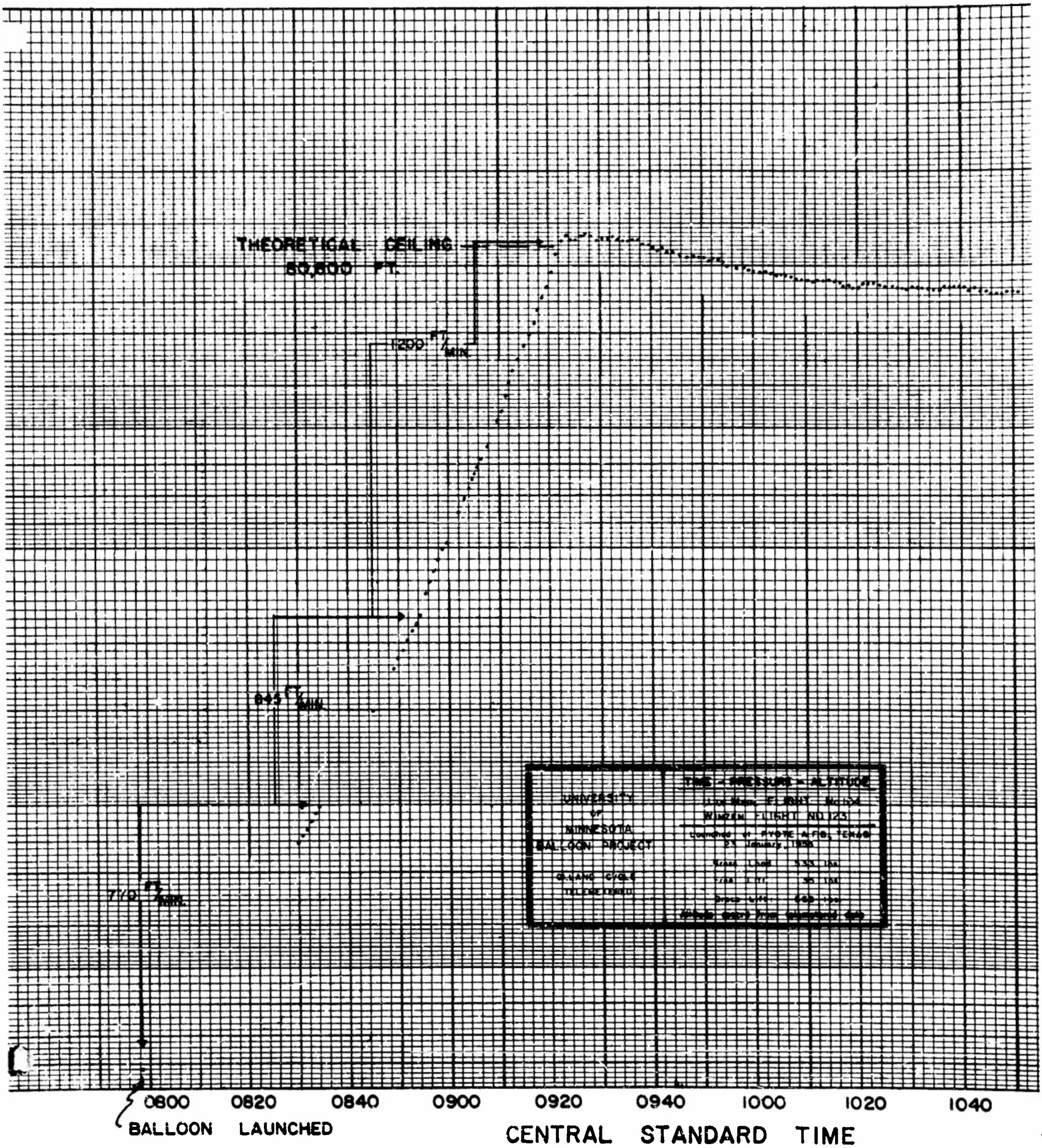

40
50
60
100
200
400
600
0500
0520
0540
0600
0620
0640
0700
0720
0740
0800
0820
0840

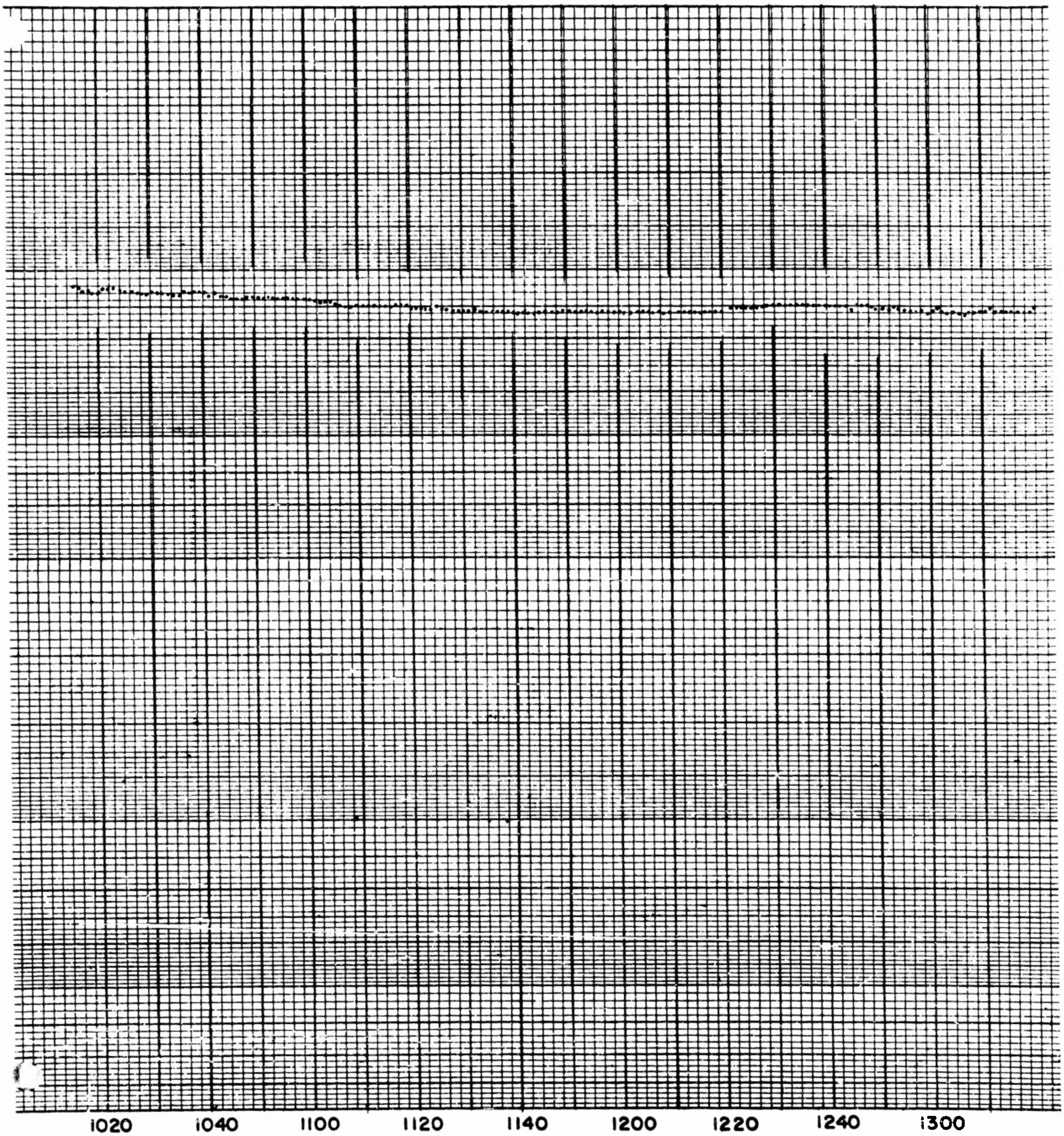

THEORETICAL CEILING
82,000 FT.
180 FT/MIN
850 FT/MIN
FT/MIN
UNIVERSITY
OF
MINNESOTA
BALLOON PROJECT
TIME - PRESSURE - ALTITUDE
U OF MINN. FLIGHT No.103
WINZEN FLIGHT NO.122
0820
0840
0900
0920
0940
1000
1020
1040
1100
1120
BALLOON LAUNCHED
CENTRAL STANDARD TIME

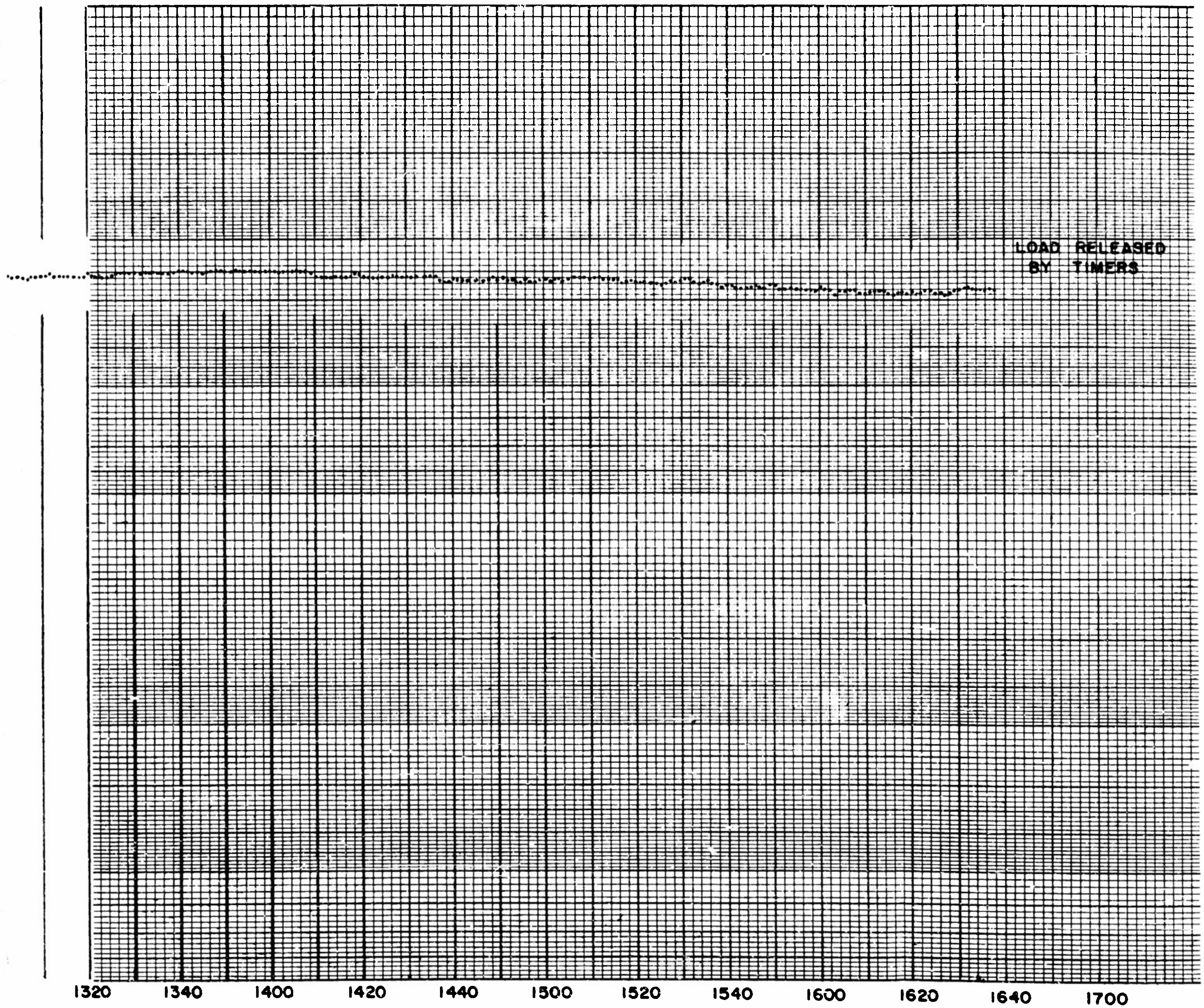

1120
1140
1200
1220
1240
1300
1320
1340
1400

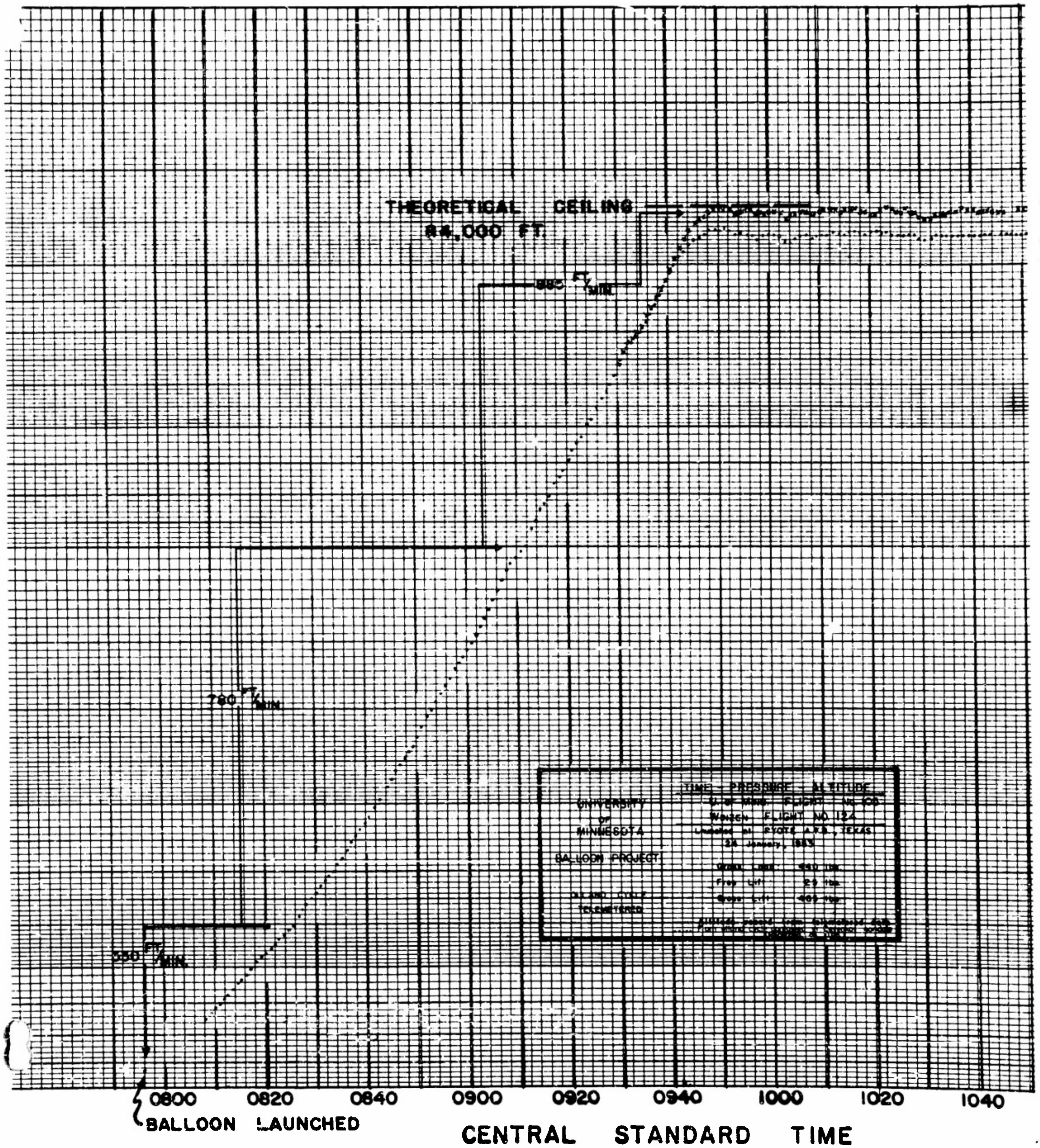

1420
1440
1500
1520
1540
1600
1620
1640
1700

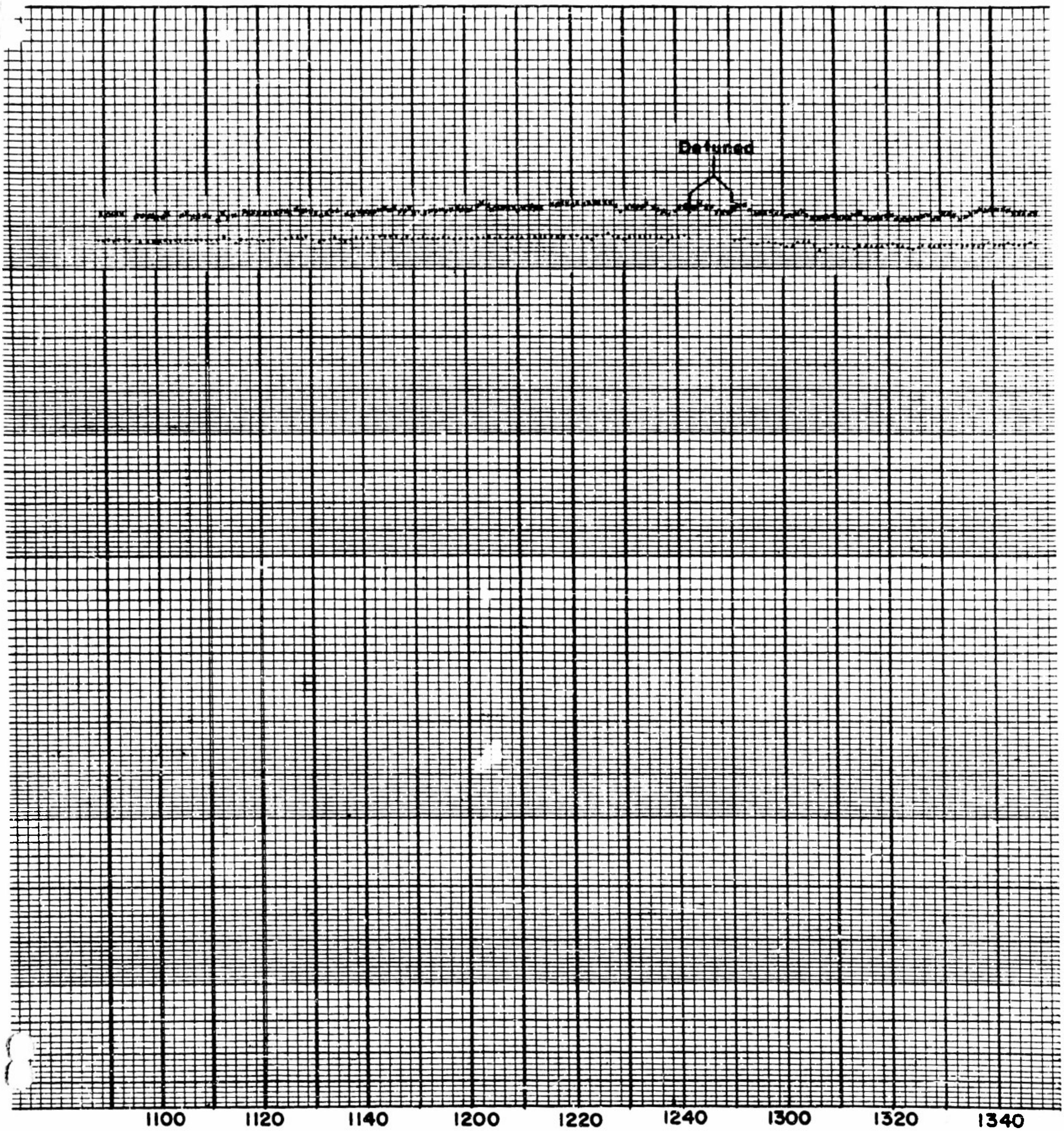

20
30
40
50
60
70
80
90
100
200
300
292 ft/min.
639 ft/min.
LOW ALTITUDE
RELEASE
1720
1740
1800
1820
1840
1900
1920
1940
2000
2020
2040

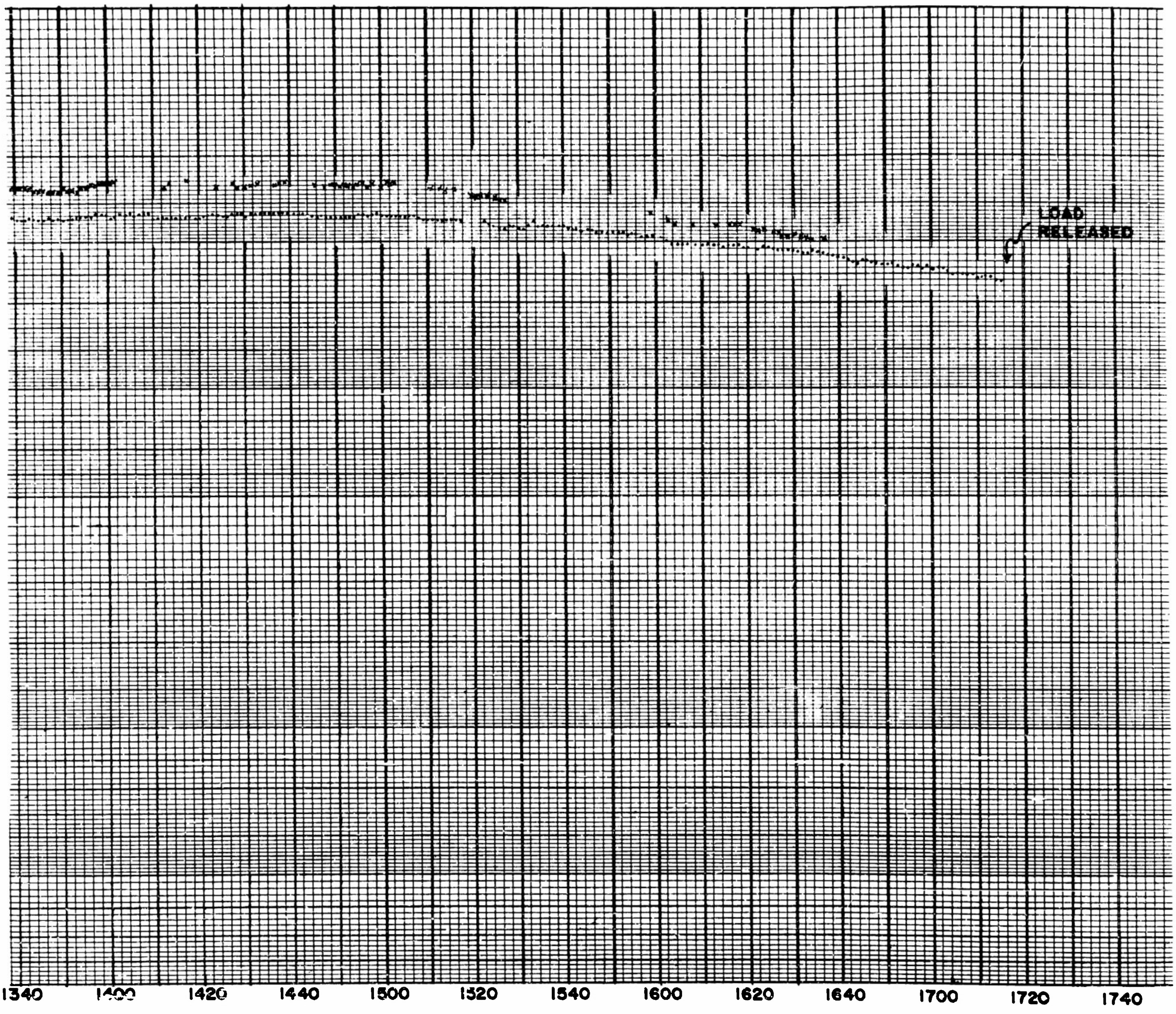

THEORETICAL CEILING
80,800 FT.
1200 FT/MIN
845 FT/MIN
770 FT/MIN.
UNIVERSITY
OF
MINNESOTA
BALLOON PROJECT
WINZEN FLIGHT NO 123
0800
0820
0840
0900
0920
0940
1000
1020
1040
BALLOON LAUNCHED
CENTRAL STANDARD TIME

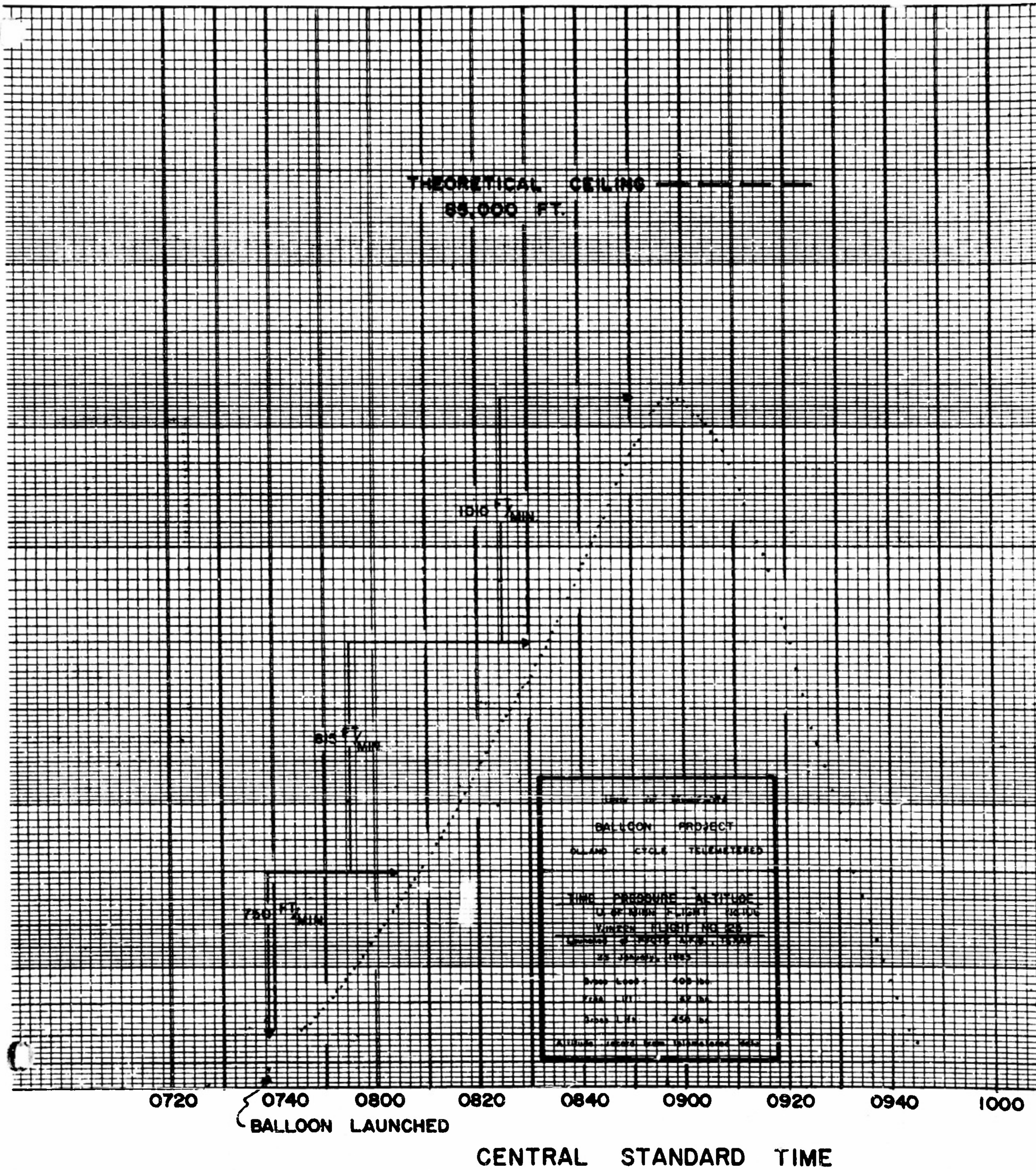

1020
1040
1100
1120
1140
1200
1220
1240
1300

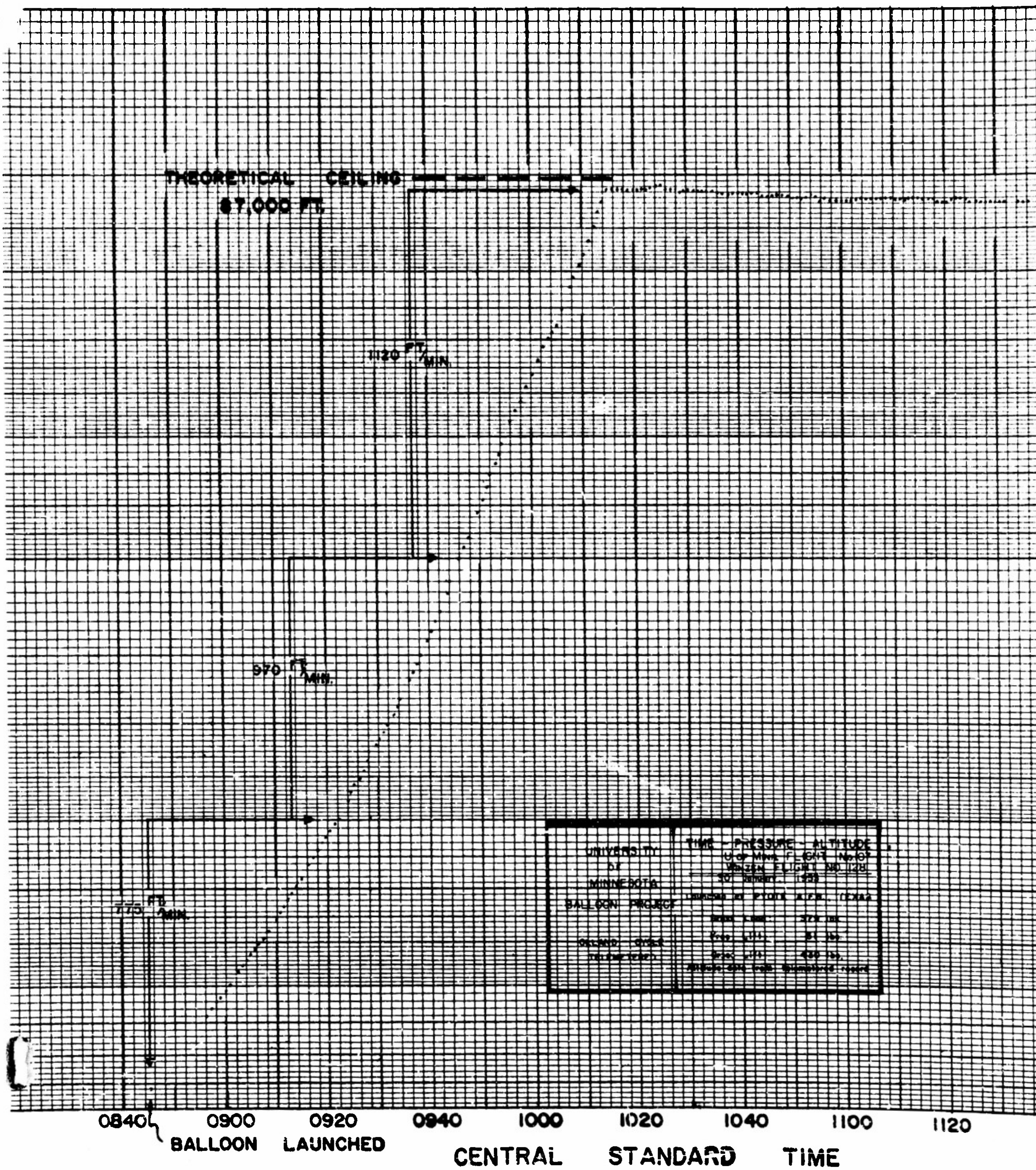

LOAD RELEASED BY TIMERS
1320
1340
1400
1420
1440
1500
1520
1540
1600
1620
1640
1700

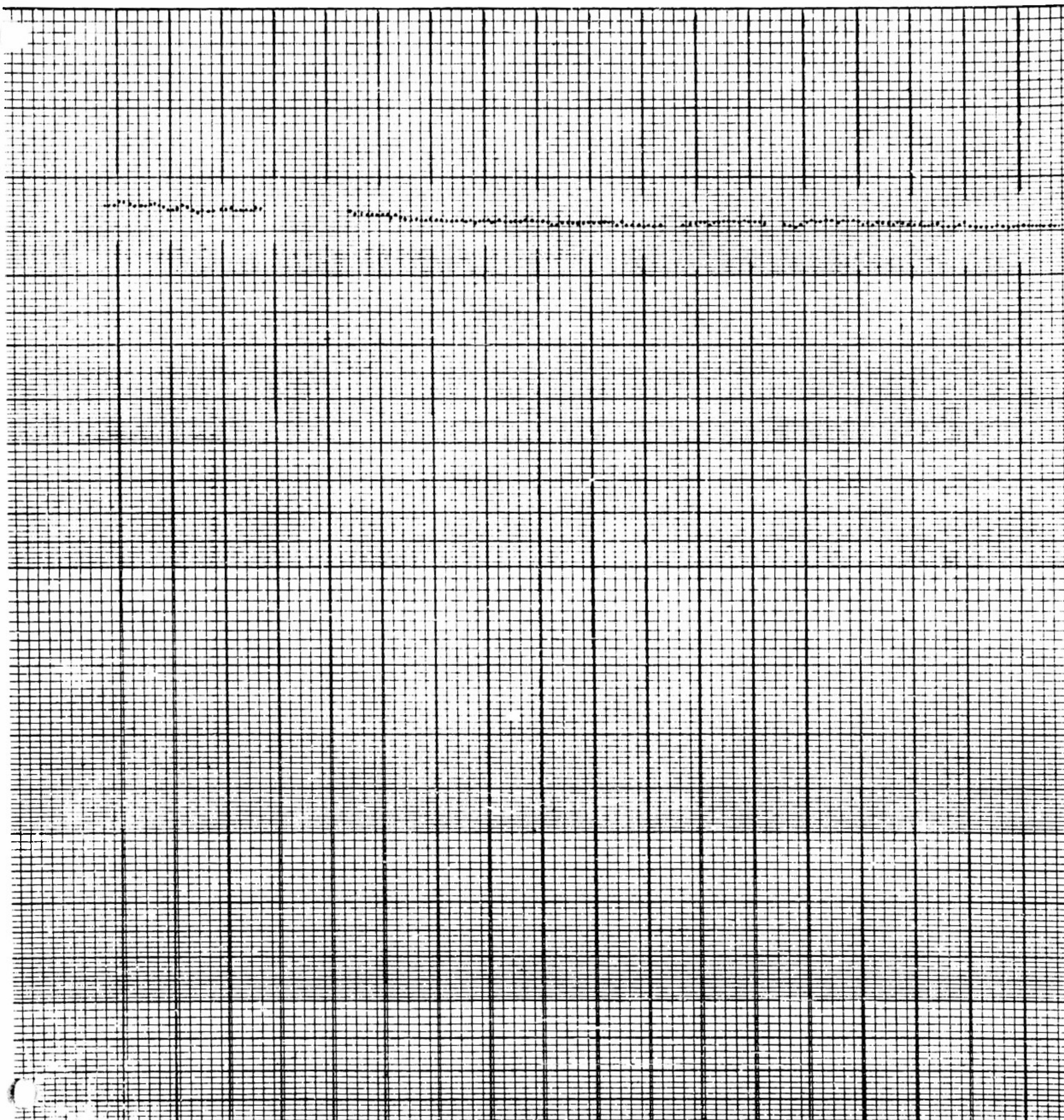

THEORETICAL CEILING
84,000 FT.
FT/MIN
780 FT/MIN
FT/MIN
UNIVERSITY
OF
MINNESOTA
BALLOON PROJECT
TELEMETERED
FLIGHT NO 124
0800
0820
0840
0900
0920
0940
1000
1020
1040
BALLOON LAUNCHED
CENTRAL STANDARD TIME

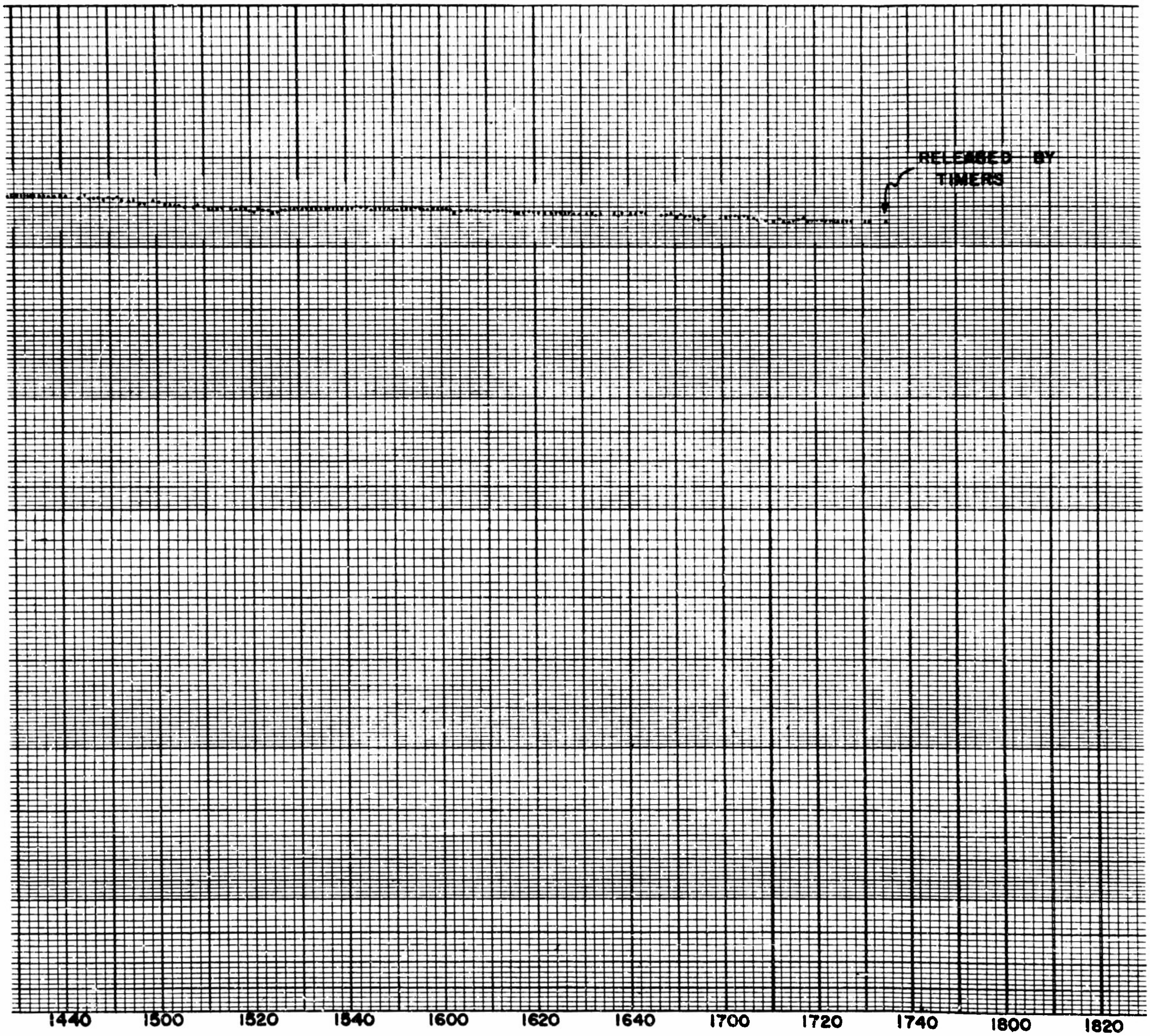

Detuned
1100
1120
1140
1200
1220
1240
1300
1320
1340

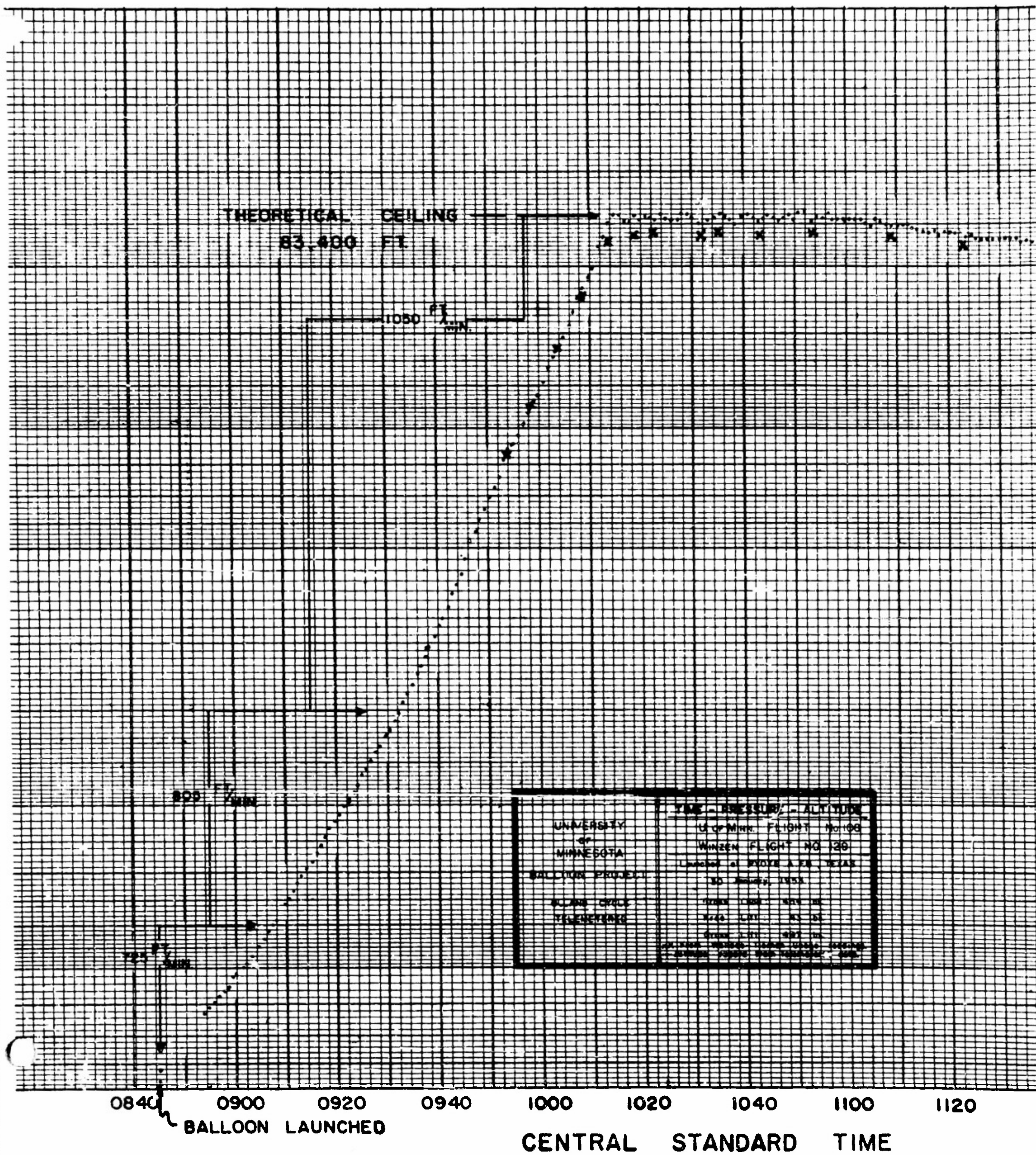

LOAD RELEASED
1340
1400
1420
1440
1500
1520
1540
1600
1620
1640
1700
1720
1740

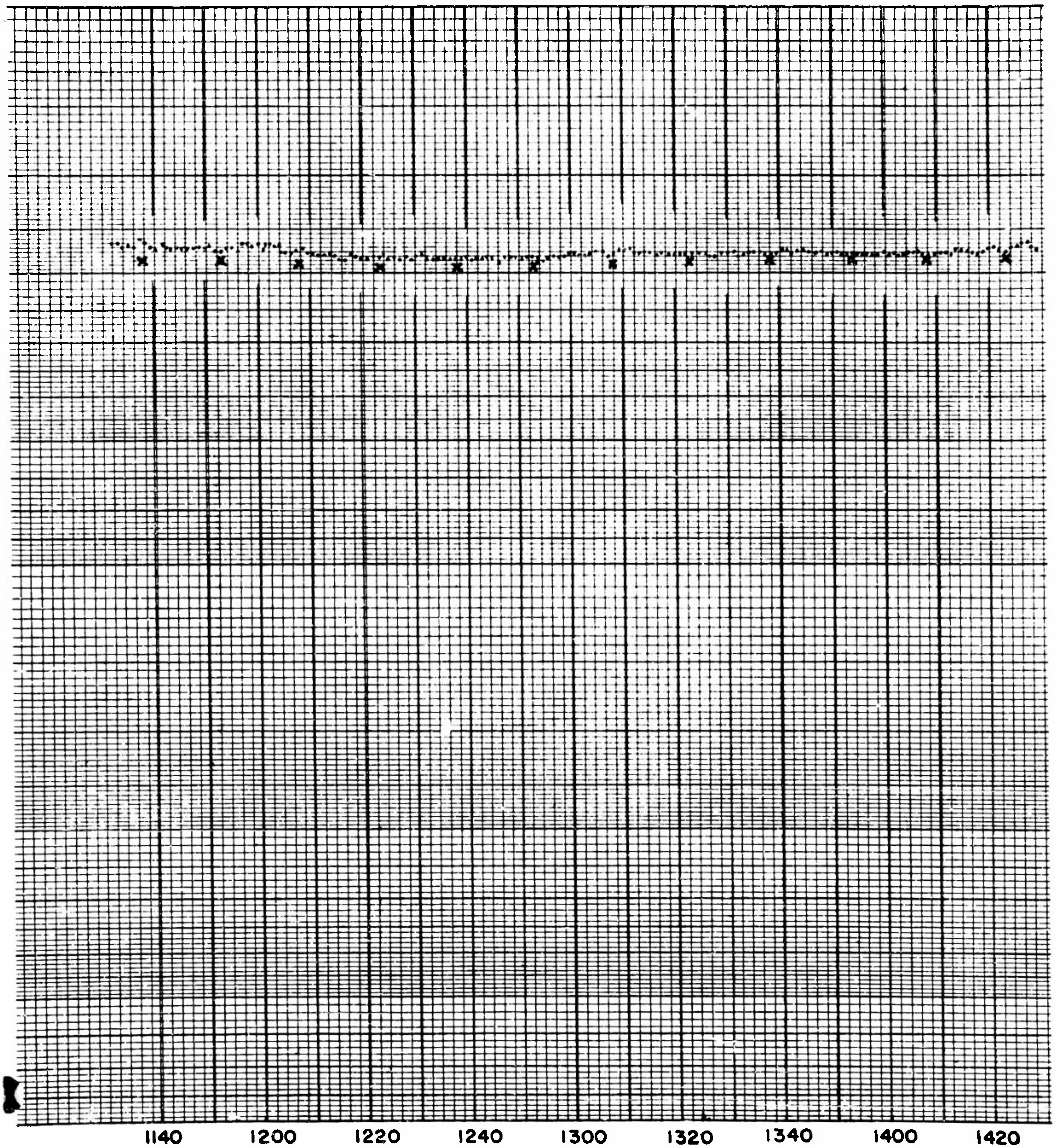

THEORETICAL CEILING
85,000 FT.
1010 FT/MIN
813 FT/MIN
750 FT/MIN
BALLOON PROJECT
TIME PRESSURE ALTITUDE
0720
0740
0800
0820
0840
0900
0920
0940
1000
BALLOON LAUNCHED
CENTRAL STANDARD TIME

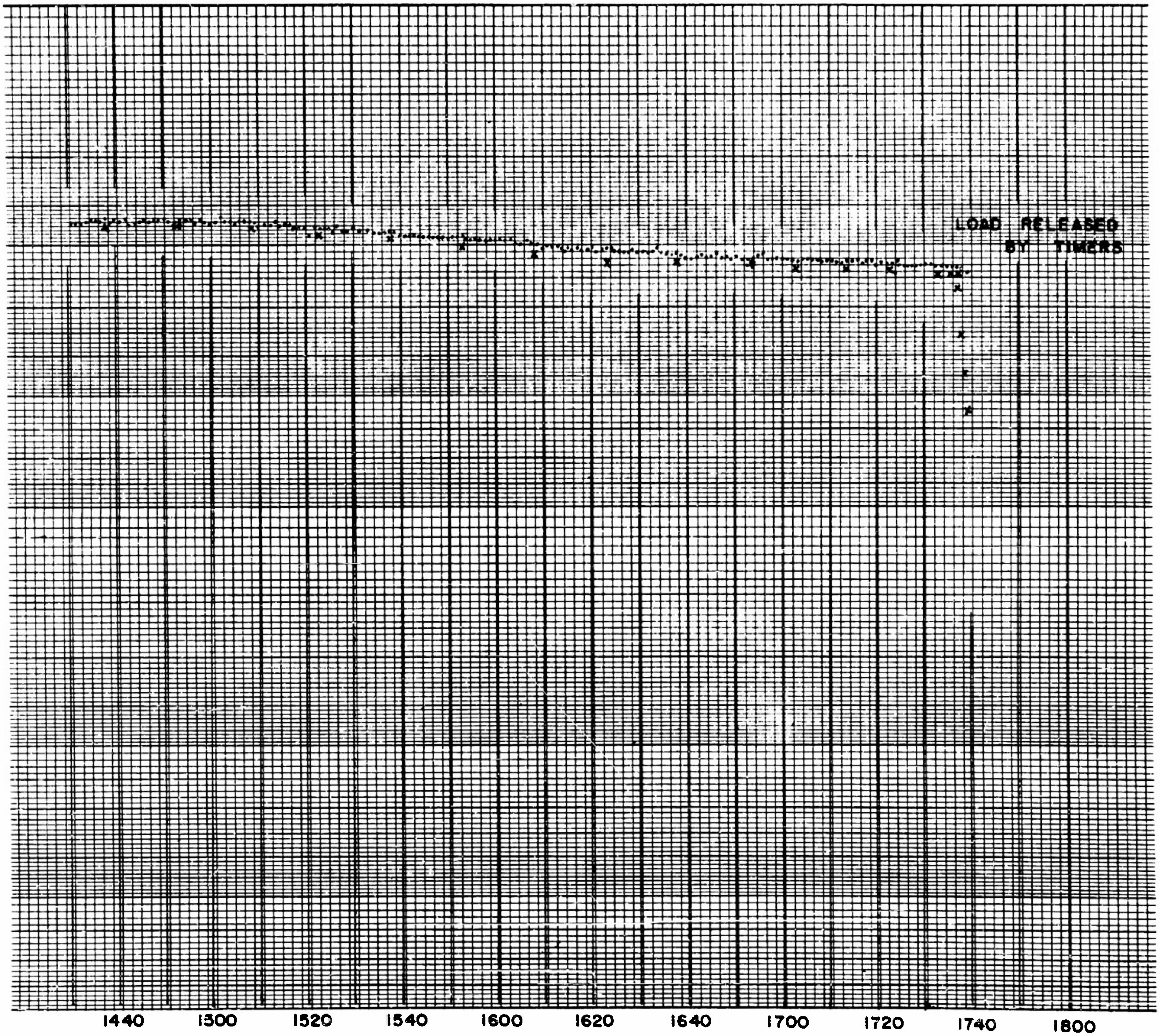

THEORETICAL CEILING
87,000 FT.
1120 FT/MIN.
970 FT/MIN.
775 FT/MIN.
UNIVERSITY
OF
MINNESOTA
BALLOON PROJECT
TIME - PRESSURE - ALTITUDE
0840
0900
0920
0940
1000
1020
1040
1100
1120
BALLOON LAUNCHED
CENTRAL STANDARD TIME

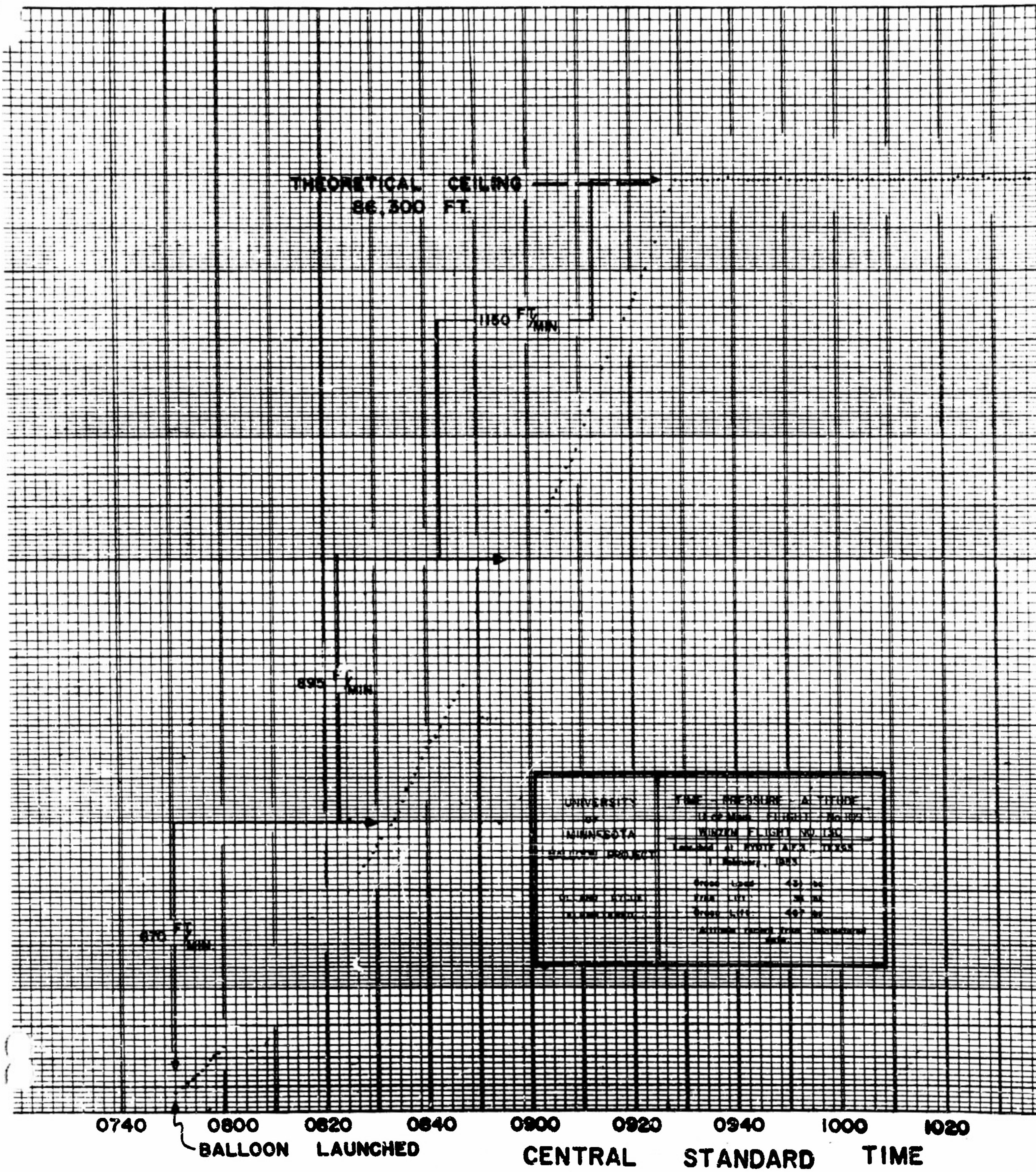

1140
1200
1220
1240
1300
1320
1340
1400
1420

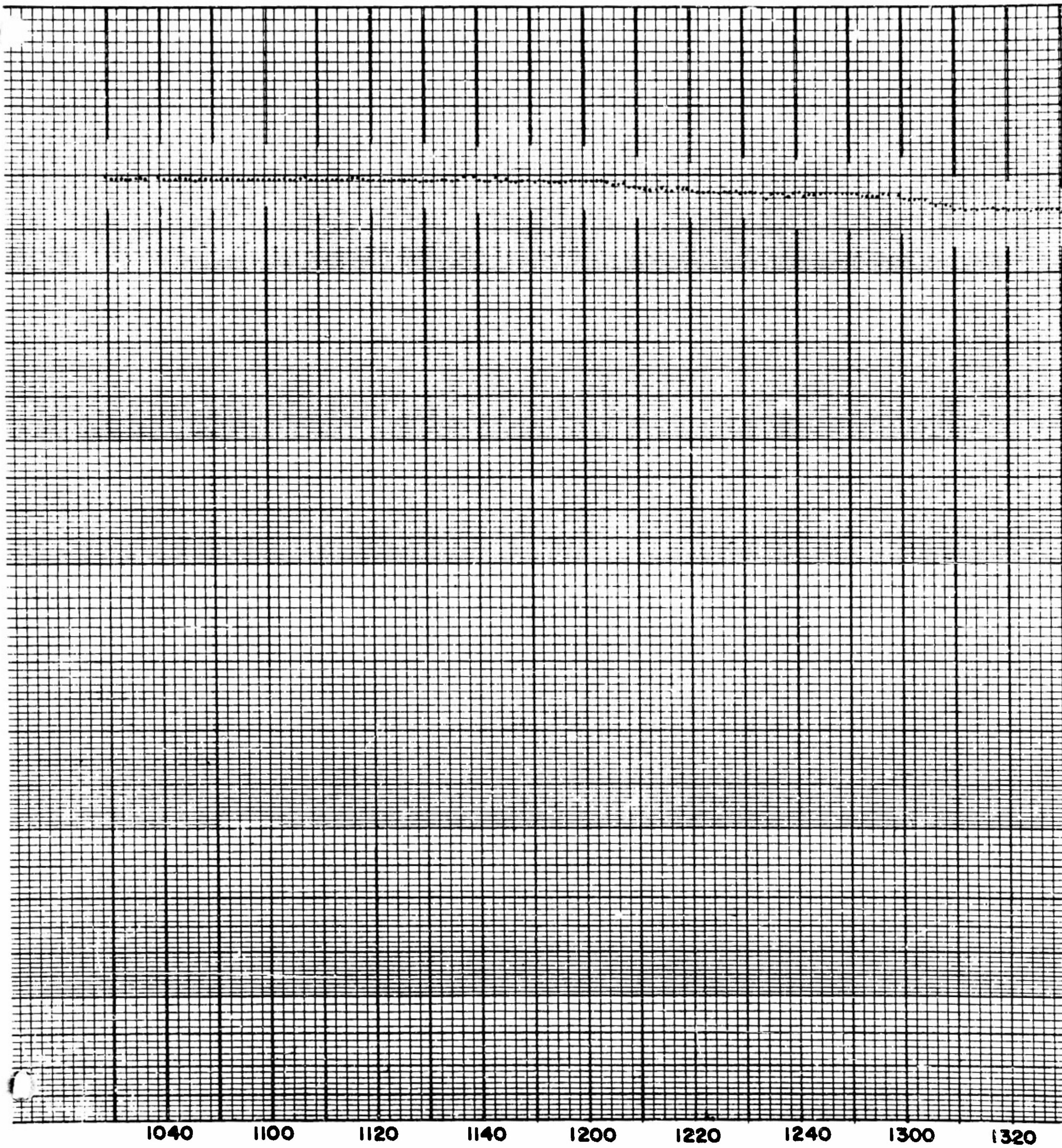

RELEASED BY
TIMERS
1440
1500
1520
1540
1600
1620
1640
1700
1720
1740
1800
1820

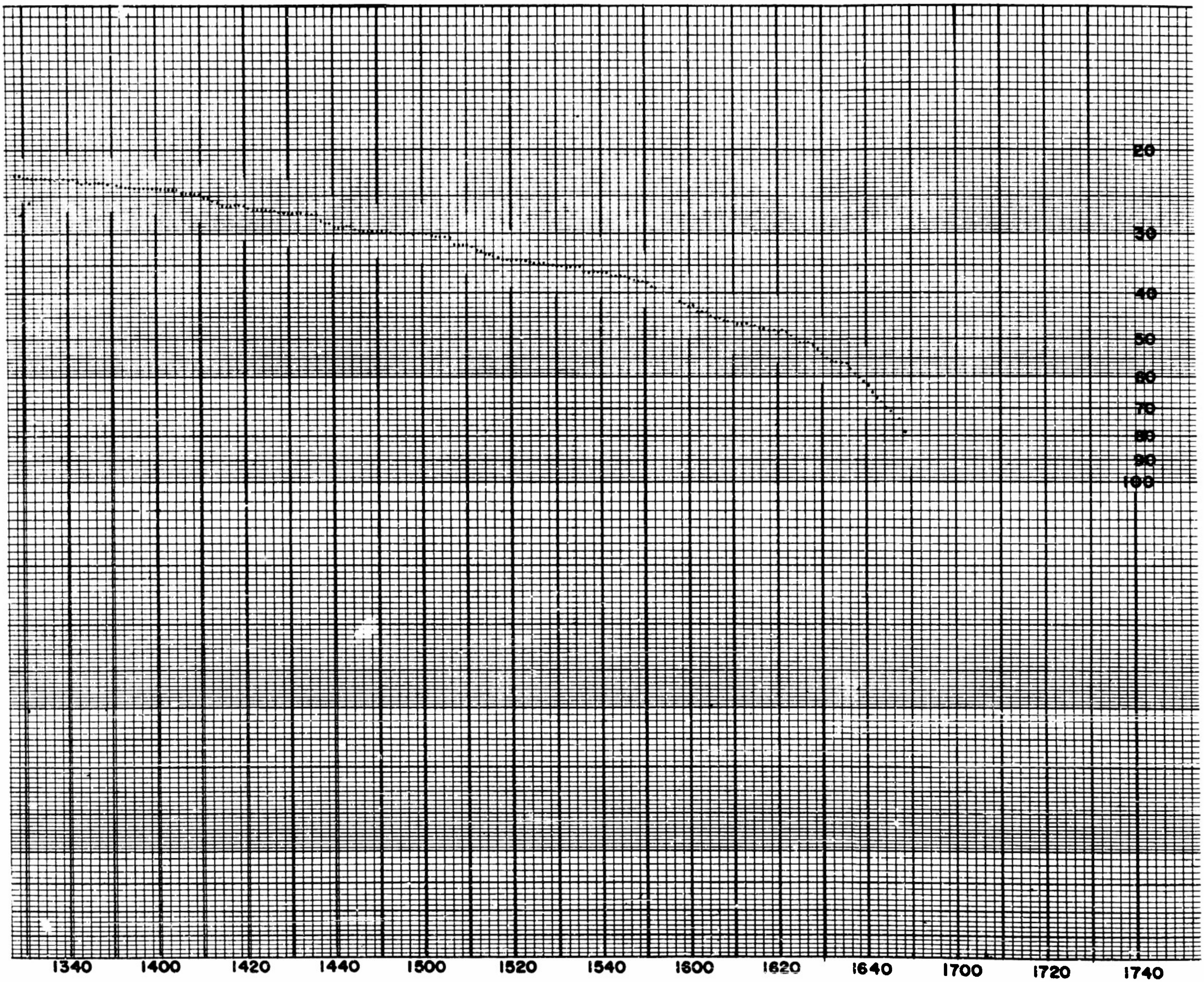

THEORETICAL CEILING
83,400 FT.
1050 FT/MIN.
800 FT/MIN
725 FT/MIN
UNIVERSITY
of
MINNESOTA
U of MINN. FLIGHT No 108
WINZEN FLIGHT NO 120
0840
0900
0920
0940
1000
1020
1040
1100
1120
BALLOON LAUNCHED
CENTRAL STANDARD TIME

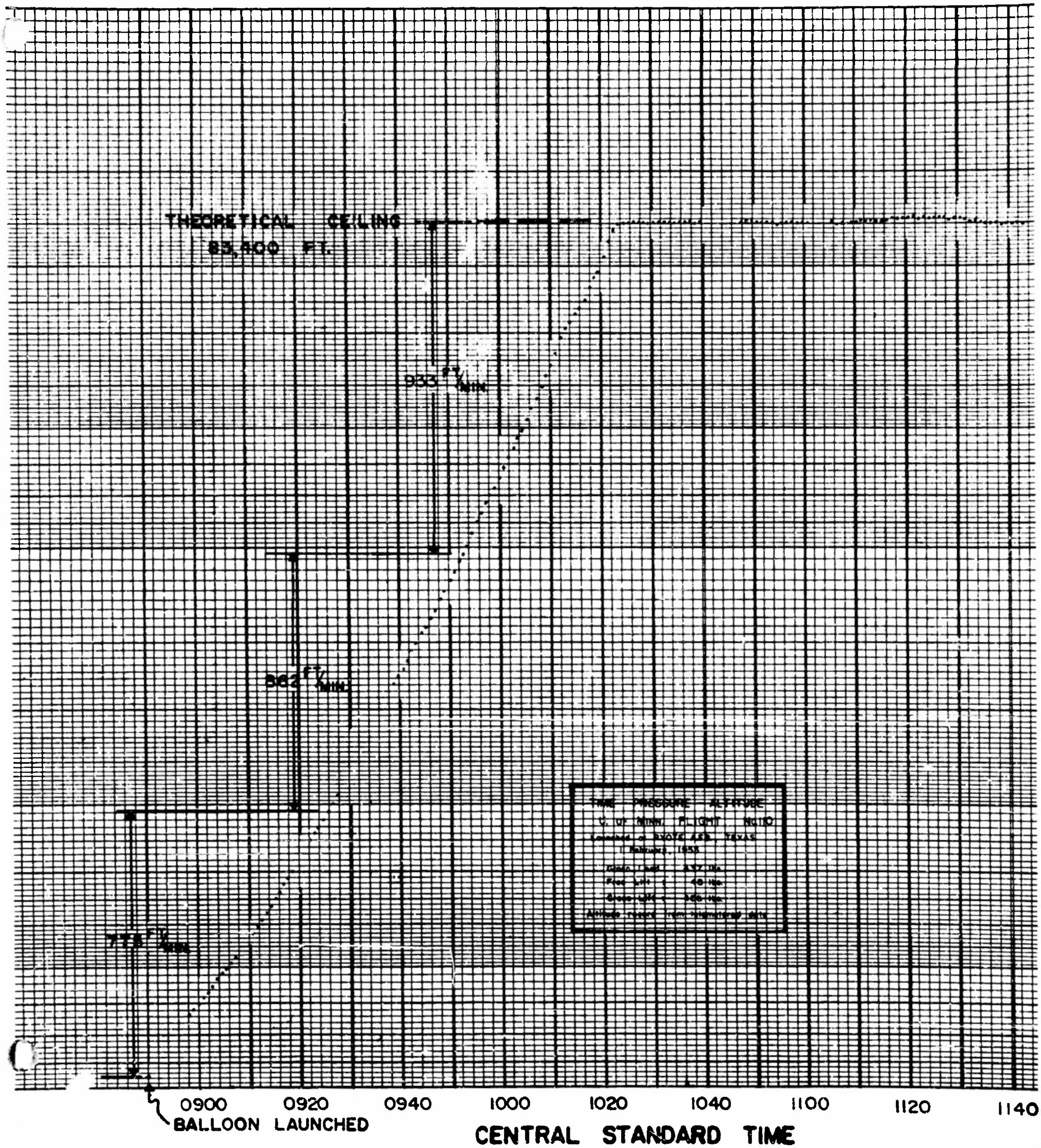

1140
1200
1220
1240
1300
1320
1340
1400
1420

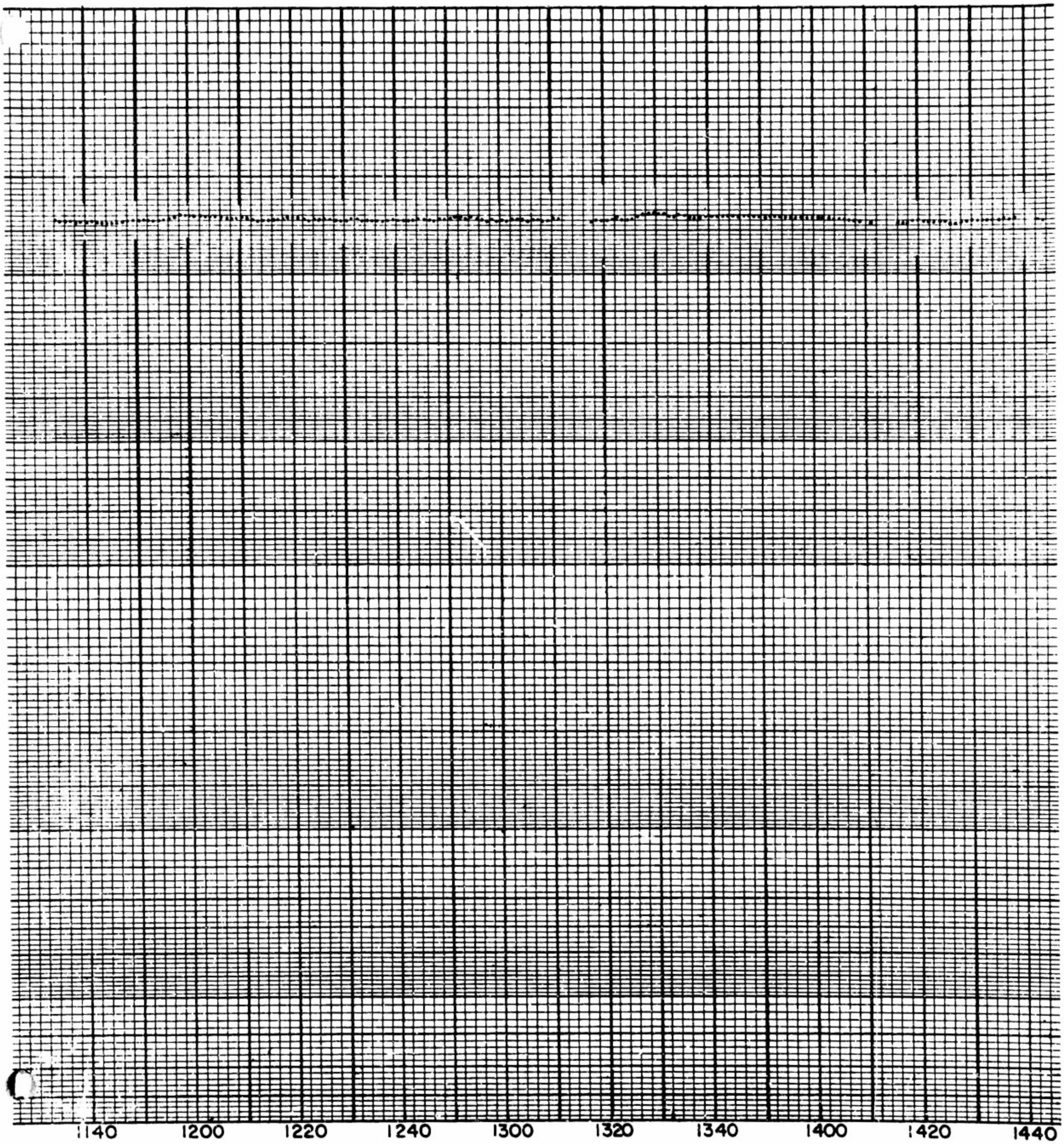

LOAD RELEASED
BY TIMERS
1440
1500
1520
1540
1600
1620
1640
1700
1720
1740
1800

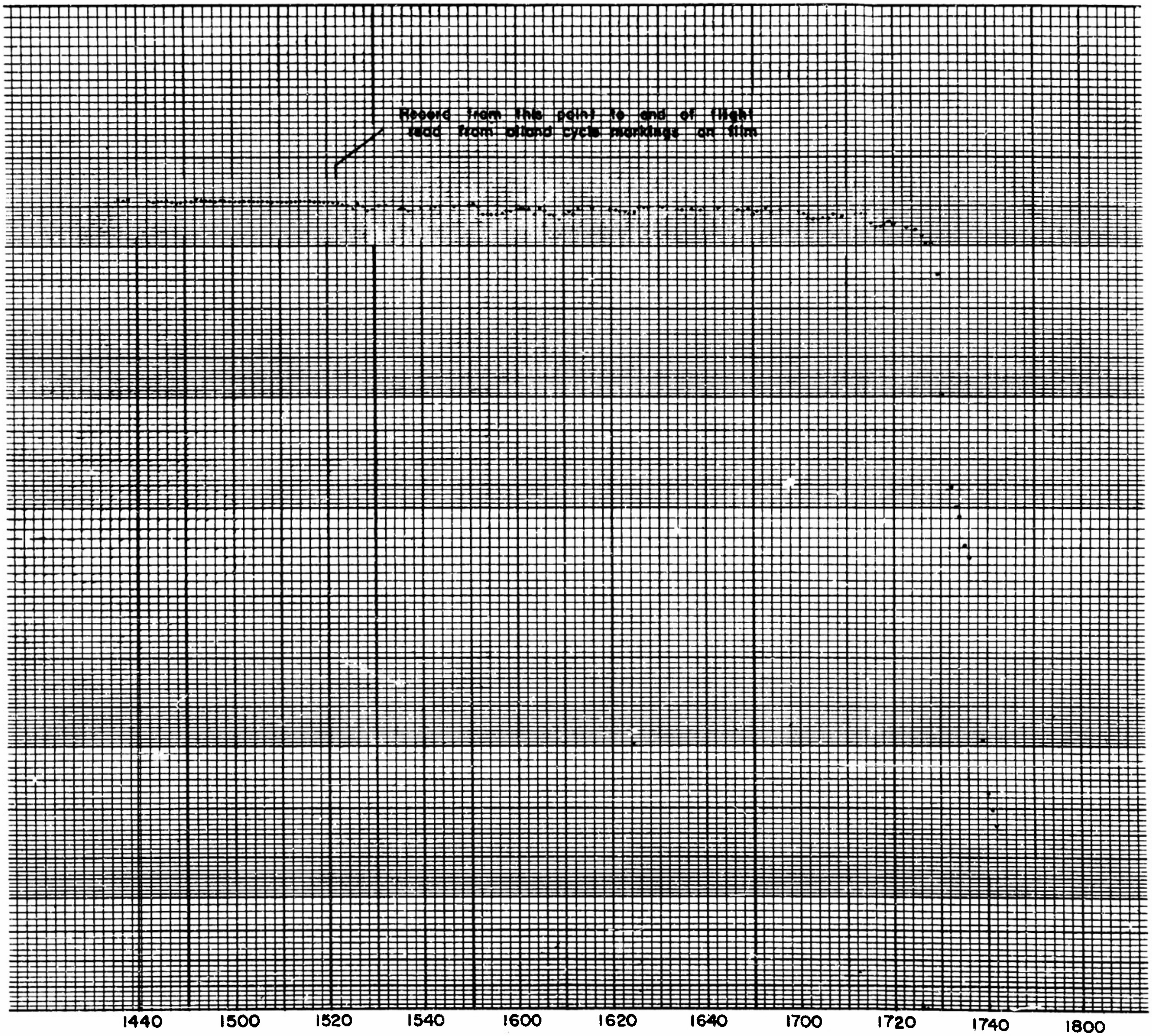

THEORETICAL CEILING
86,300 FT.
1150 FT/MIN
895 FT/MIN
870 FT/MIN
UNIVERSITY
OF
MINNESOTA
TIME - PRESSURE - ALTITUDE
WINZEN FLIGHT NO. 130
0740
0800
0820
0840
0900
0920
0940
1000
1020
BALLOON LAUNCHED
CENTRAL STANDARD TIME

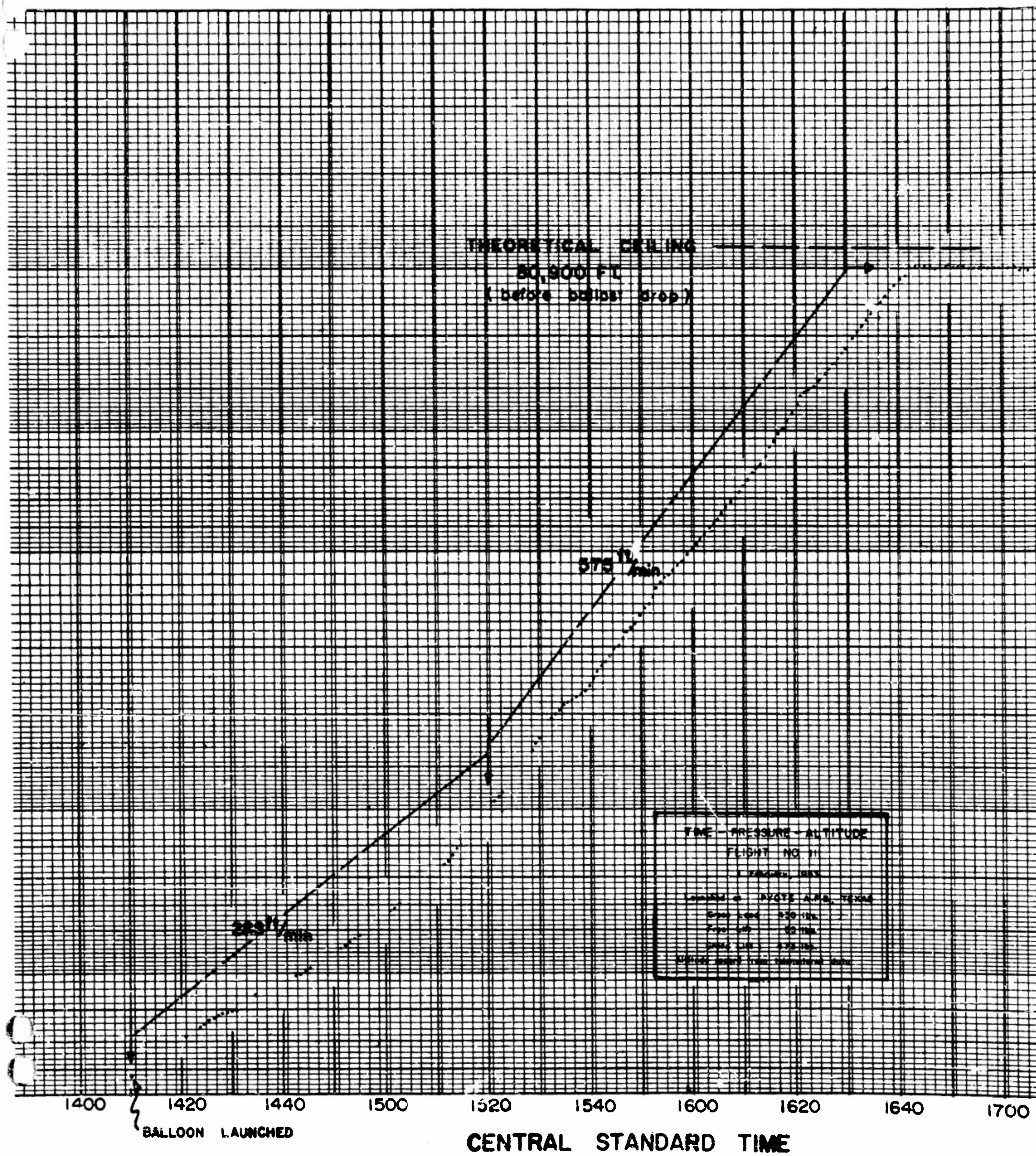

1040
1100
1120
1140
1200
1220
1240
1300
1320

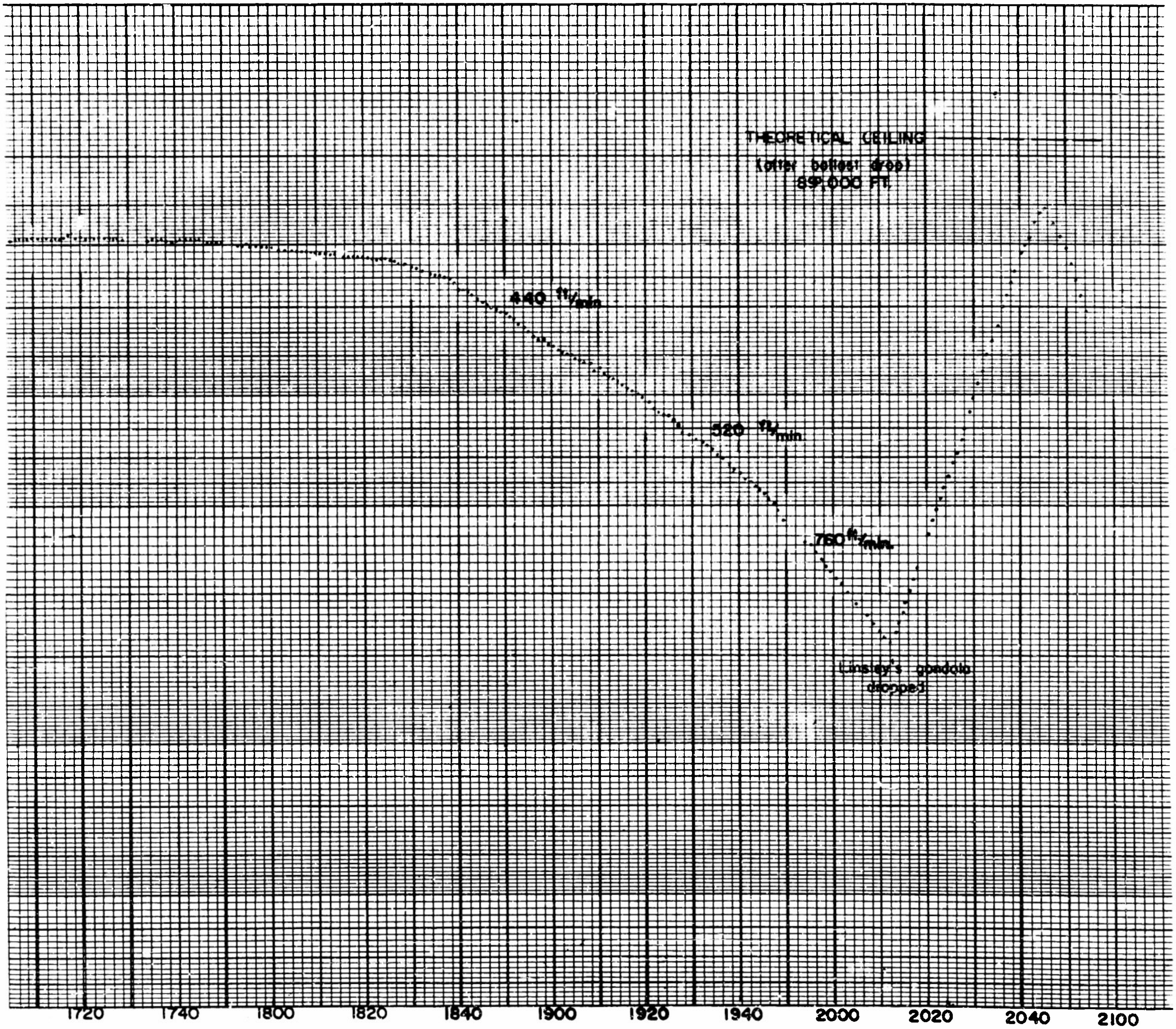

20
30
40
50
60
70
80
90
100
1340
1400
1420
1440
1500
1520
1540
1600
1620
1640
1700
1720
1740

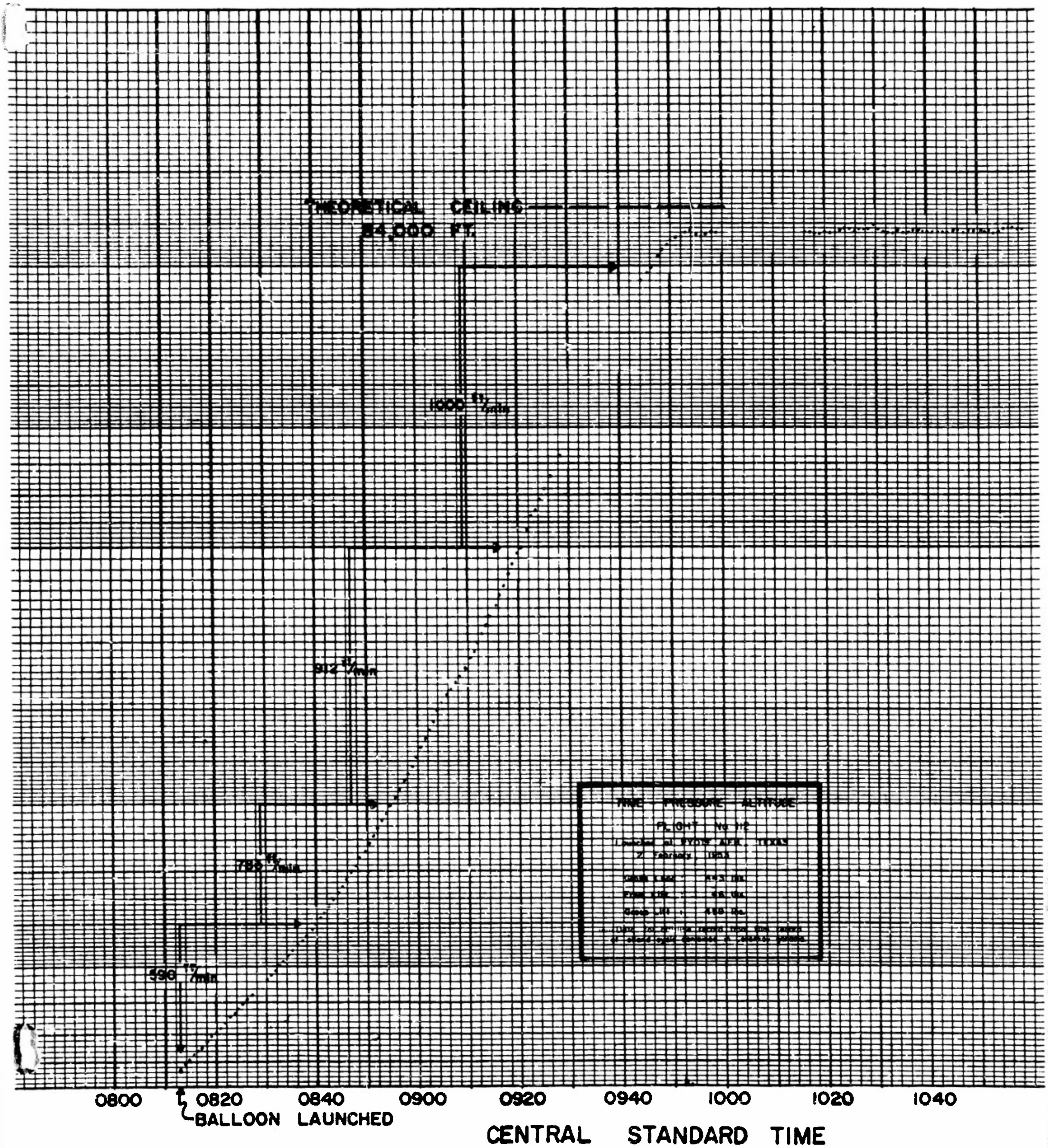

THEORETICAL CEILING
83,400 FT.
933 FT/MIN.
862 FT/MIN.
775 FT/MIN.
TIME - PRESSURE - ALTITUDE
U. OF MINN. FLIGHT NO.10
Launched at PYOTE AFB, TEXAS
0900
0920
0940
1000
1020
1040
1100
1120
1140
BALLOON LAUNCHED
CENTRAL STANDARD TIME

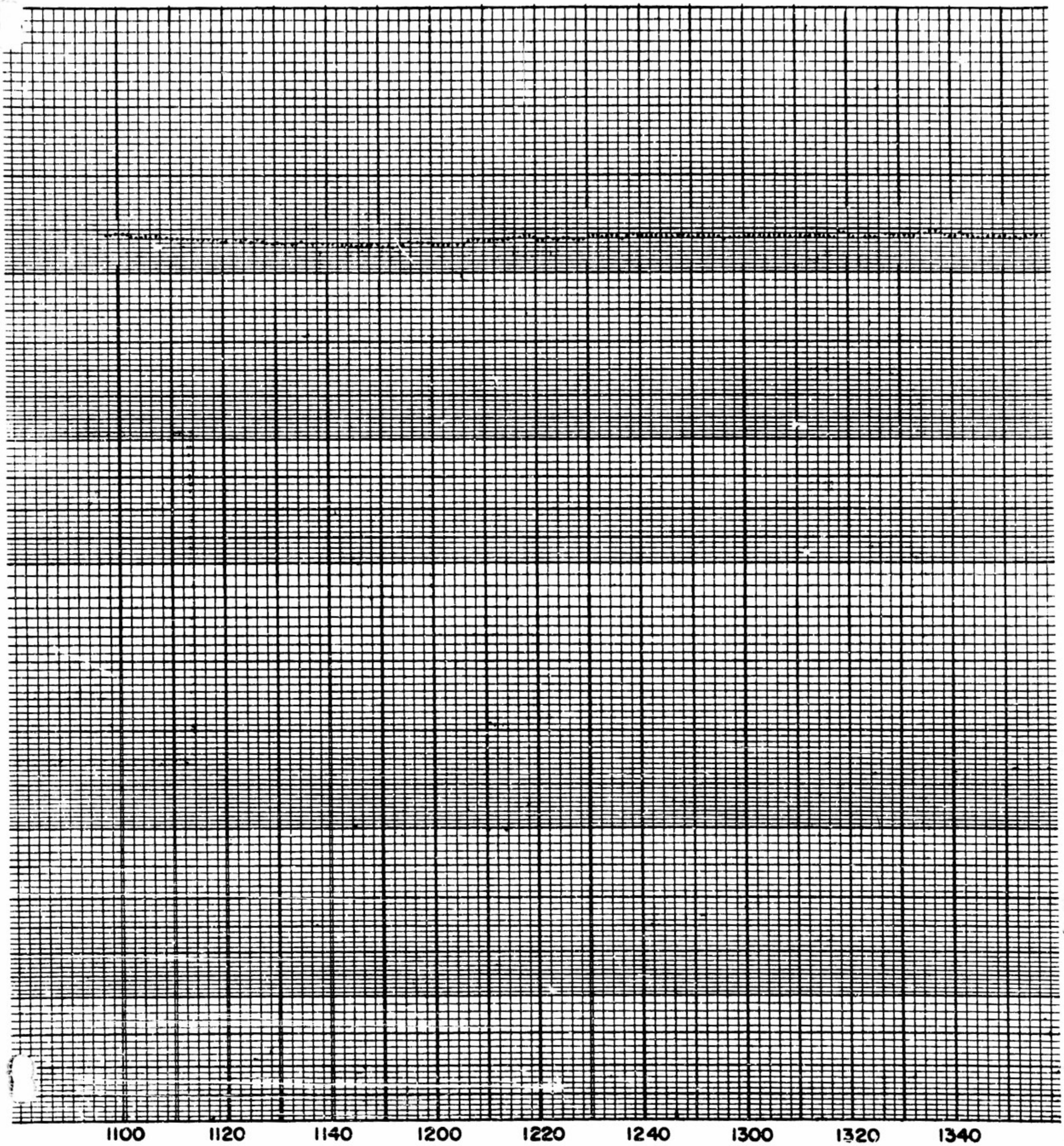

1140
1200
1220
1240
1300
1320
1340
1400
1420
1440

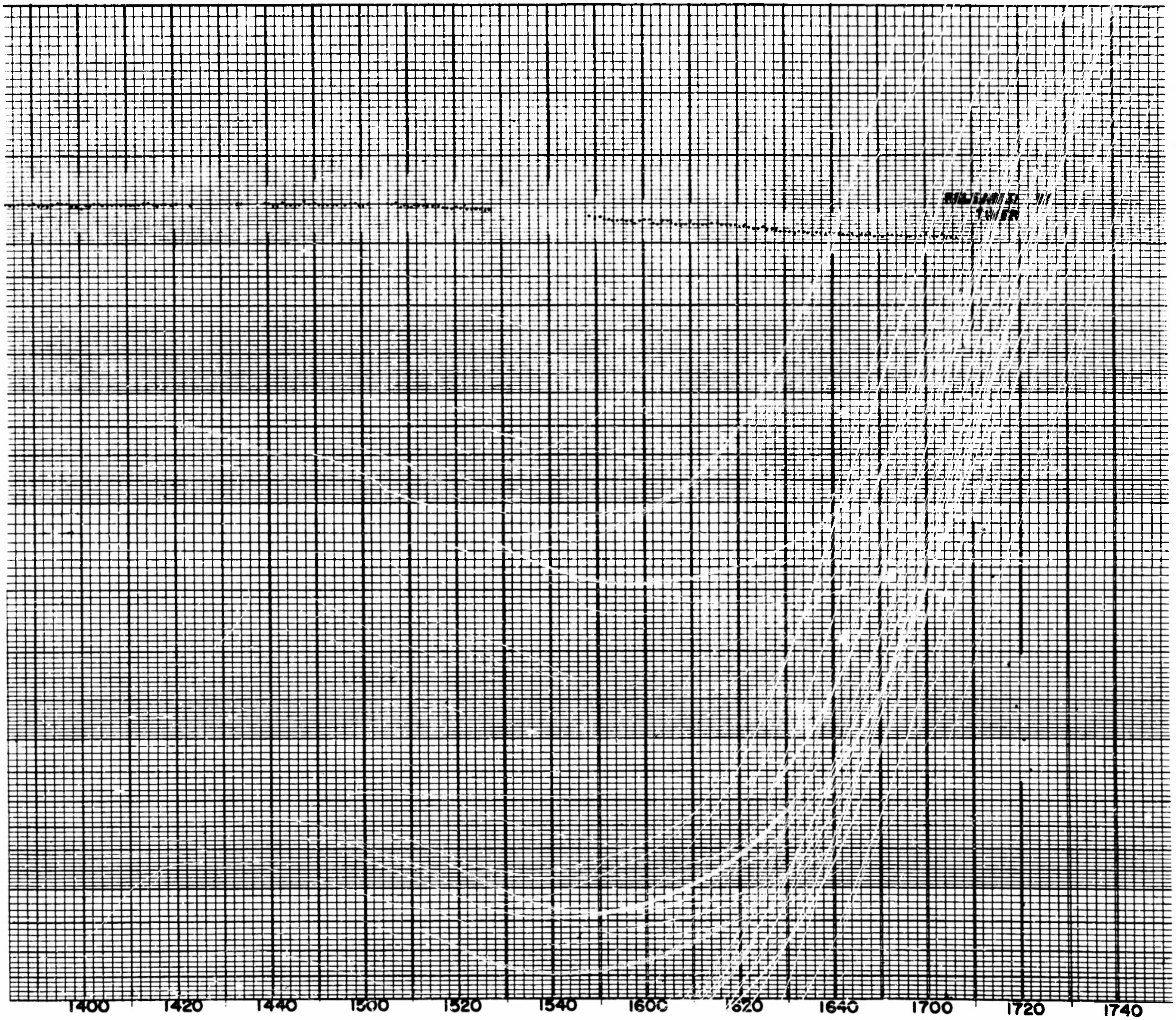

Record from this point to end of flight
read from cycle markings on film
1440
1500
1520
1540
1600
1620
1640
1700
1720
1740
1800

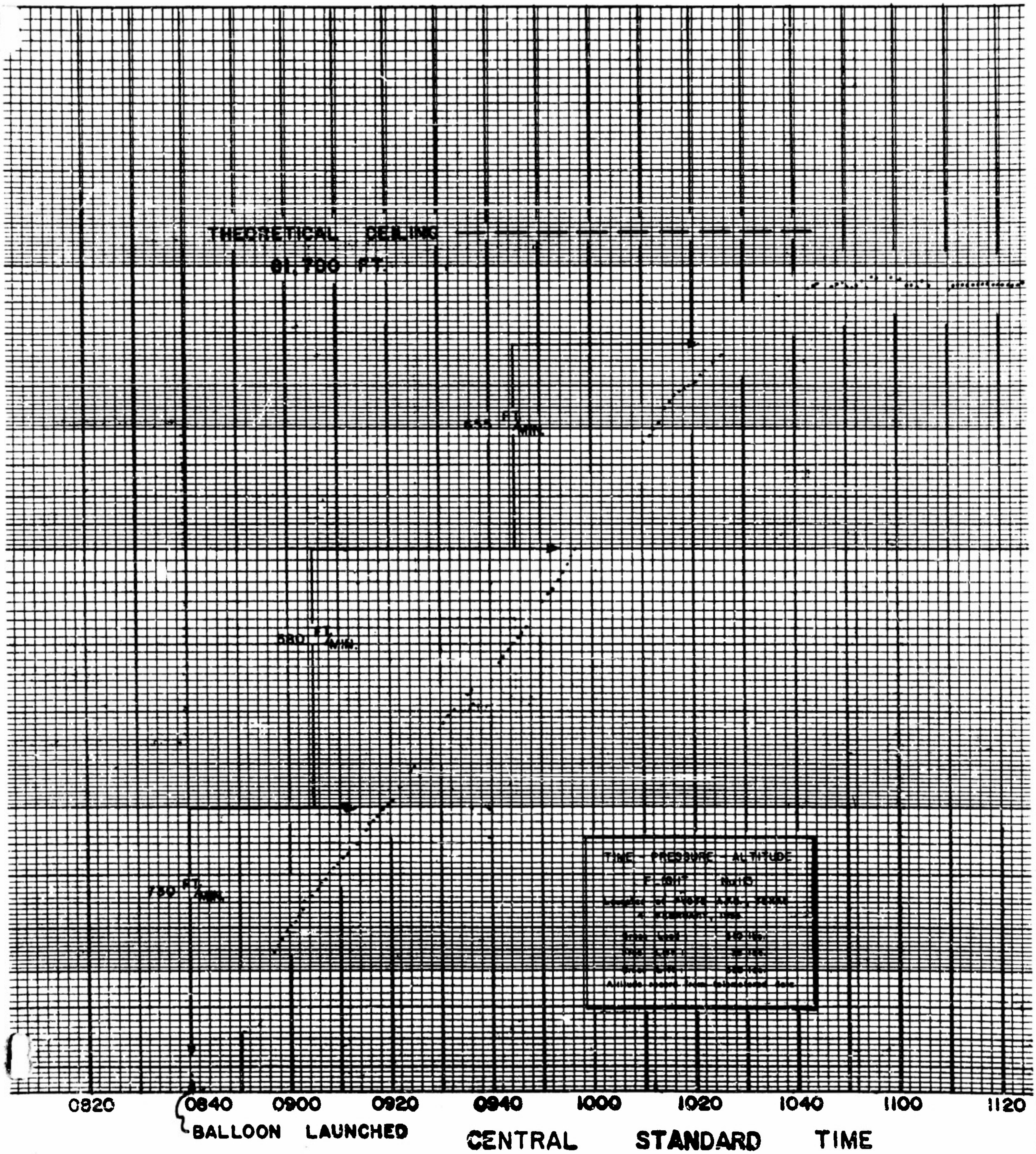

THEORETICAL CEILING
80,900 FT
(before ballast drop)
575 ft/min
283 ft/min
TIME - PRESSURE - ALTITUDE
FLIGHT NO. 11
1400
1420
1440
1500
1520
1540
1600
1620
1640
1700
BALLOON LAUNCHED
CENTRAL STANDARD TIME

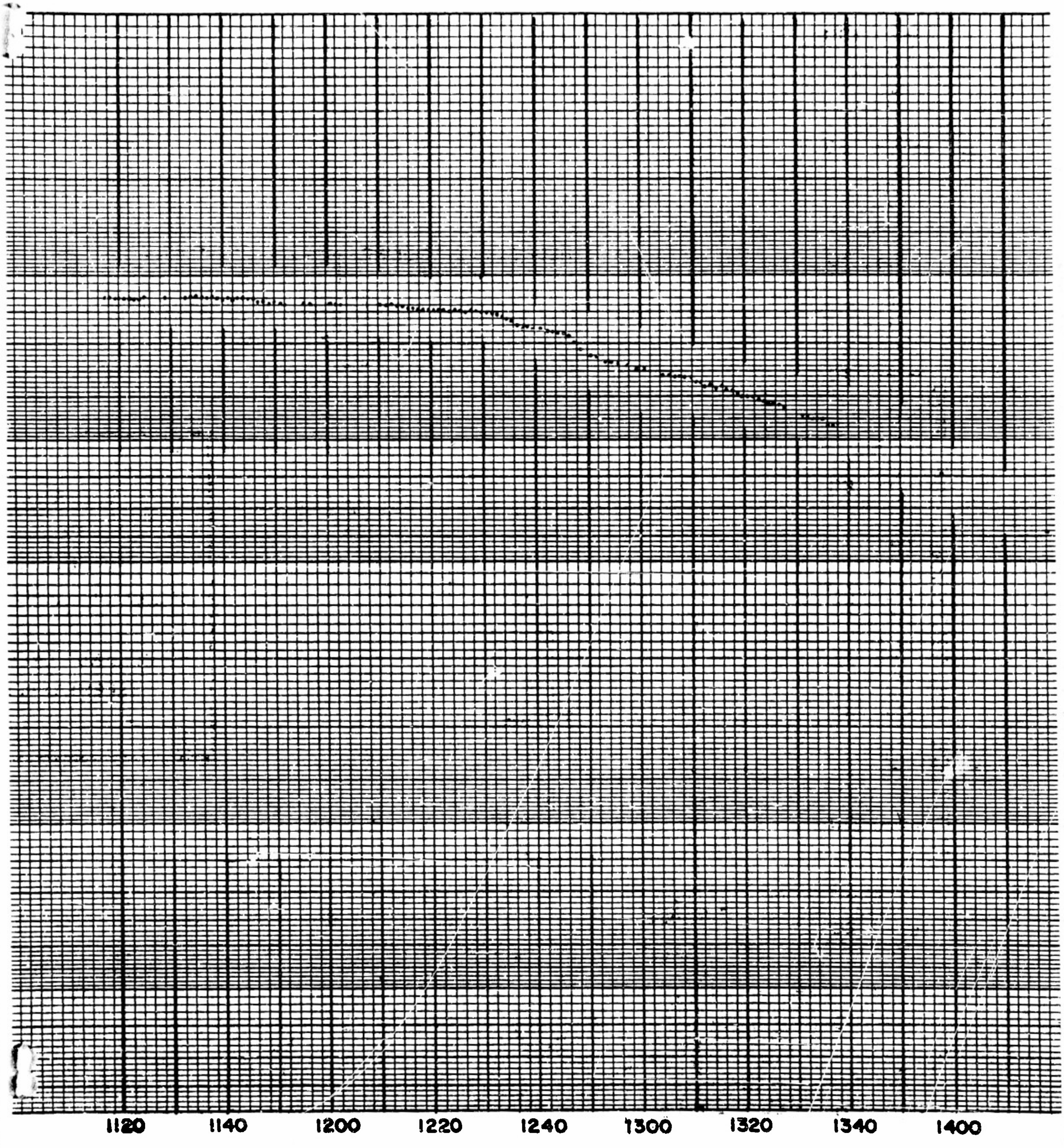

THEORETICAL CEILING
(after ballast drop)
89,000 FT.
440 ft/min
520 ft/min
760 ft/min
Linsley's gondola dropped
1720
1740
1800
1820
1840
1900
1920
1940
2000
2020
2040
2100

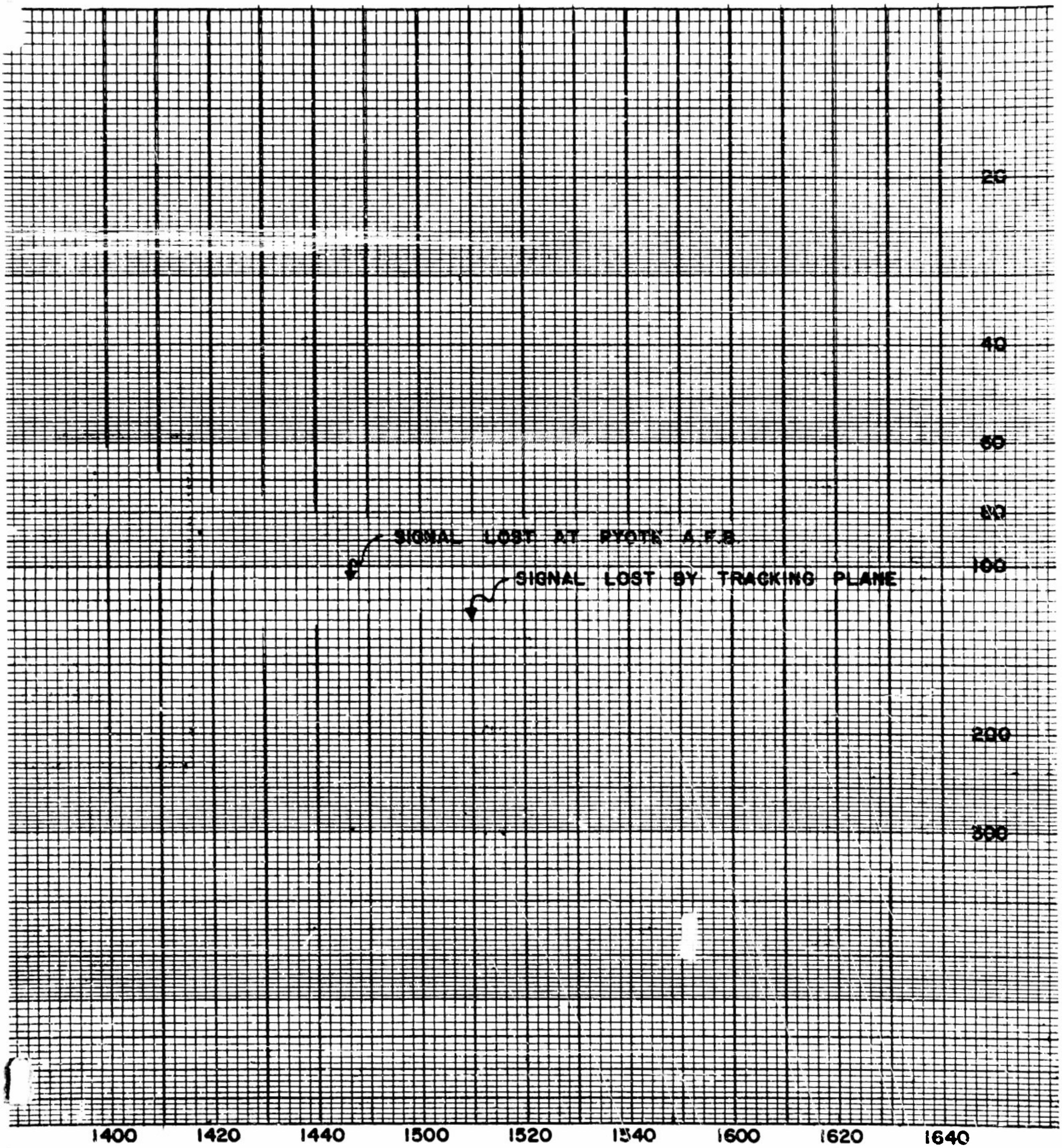

THEORETICAL CEILING
1000 ft/min
912 ft/min
TIME PRESSURE ALTITUDE
0800
0820
0840
0900
0920
0940
1000
1020
1040
BALLOON LAUNCHED
CENTRAL STANDARD TIME


1100
1120
1140
1200
1220
1240
1300
1320
1340

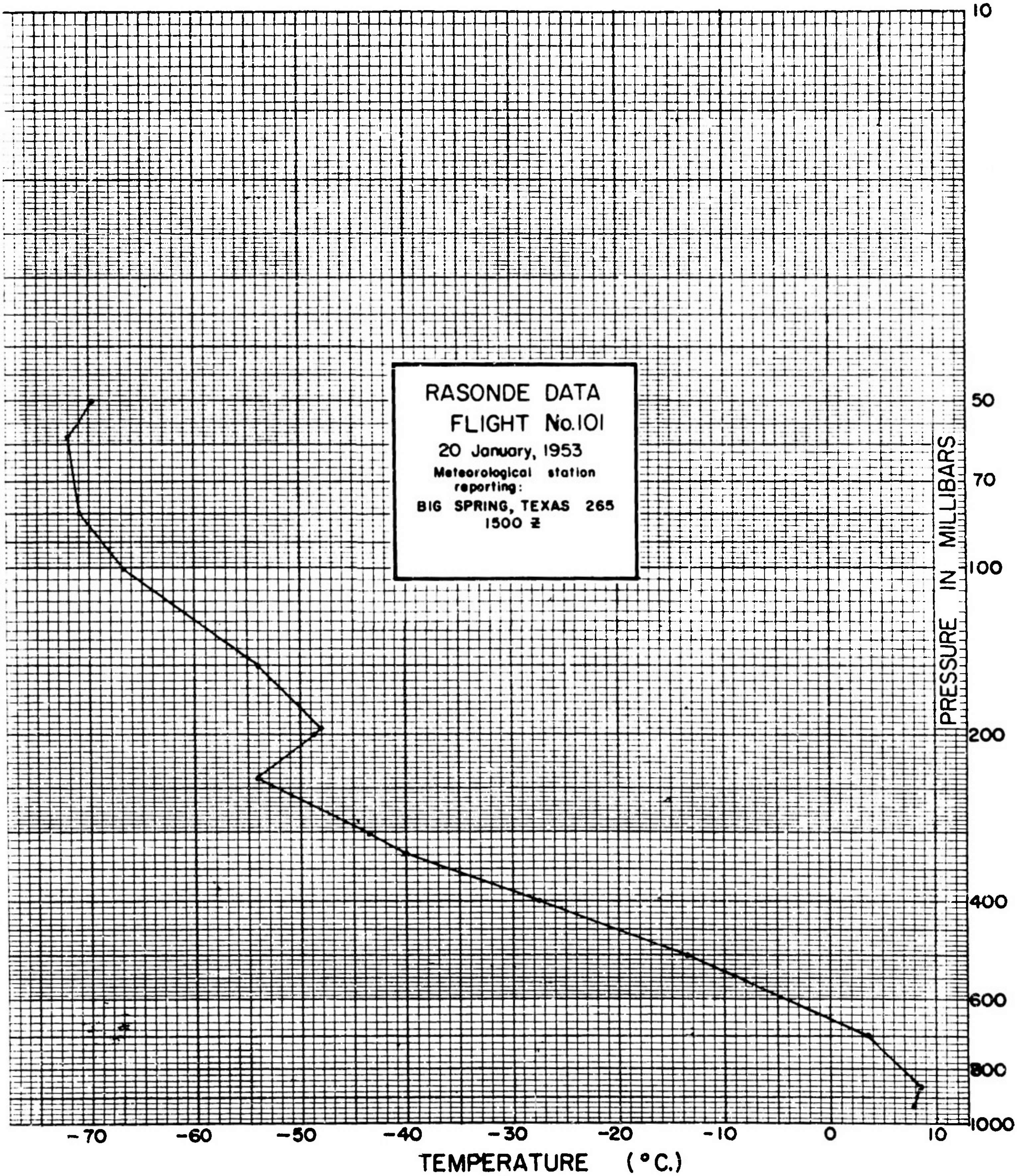

1400
1420
1440
1500
1520
1540
1600
1620
1640
1700
1720
1740


THEORETICAL CEILING
81,700 FT.
750 FT/MIN.
580 FT/MIN.
TIME - PRESSURE - ALTITUDE
0820
0840
0900
0920
0940
1000
1020
1040
1100
1120
BALLOON LAUNCHED
CENTRAL STANDARD TIME


1120
1140
1200
1220
1240
1300
1320
1340
1400

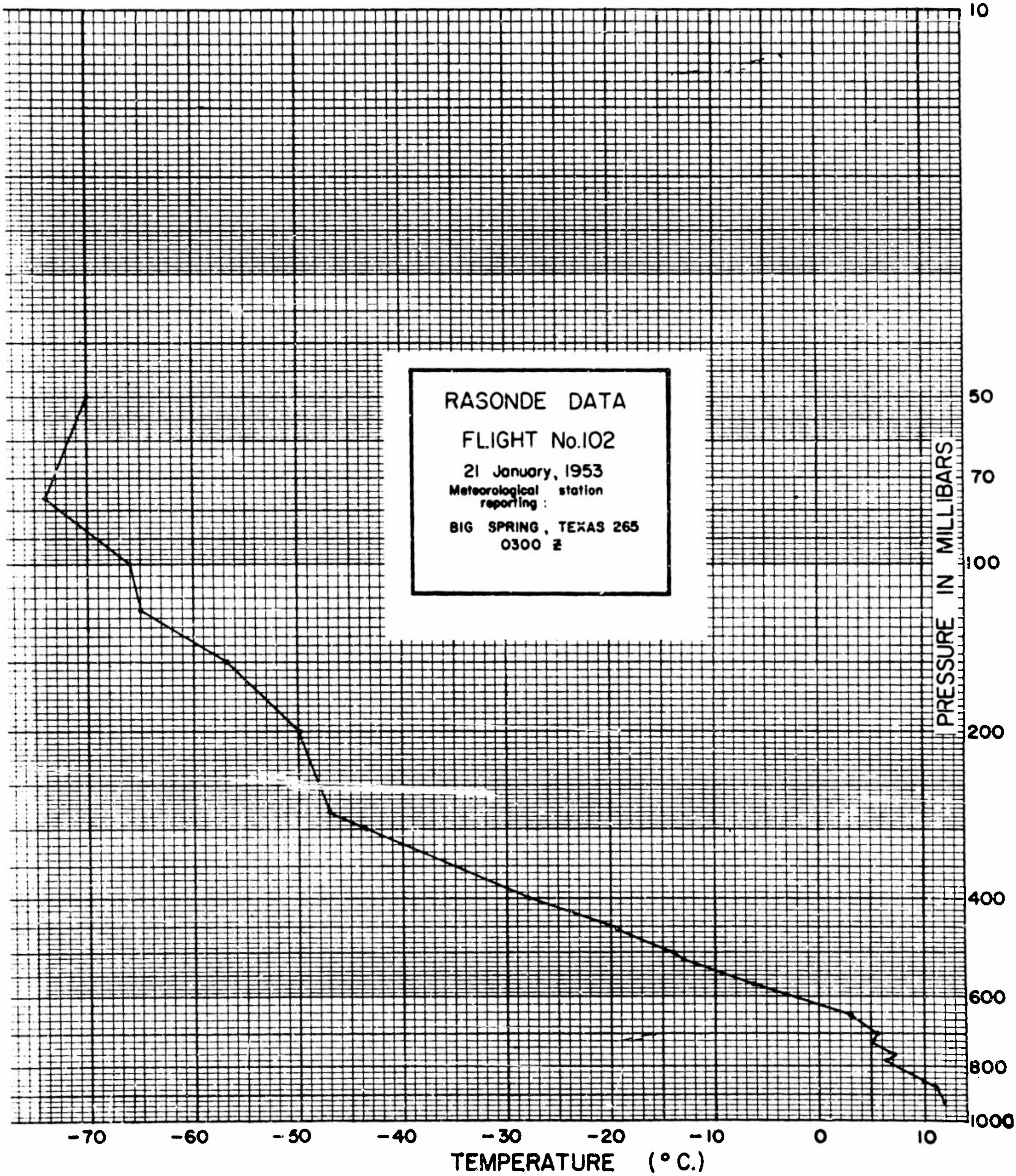

SIGNAL LOST AT RYOTK A.F.B.
SIGNAL LOST BY TRACKING PLANE
20
40
60
80
100
200
300
1400
1420
1440
1500
1520
1540
1600
1620
1640

CONFIDENTIAL



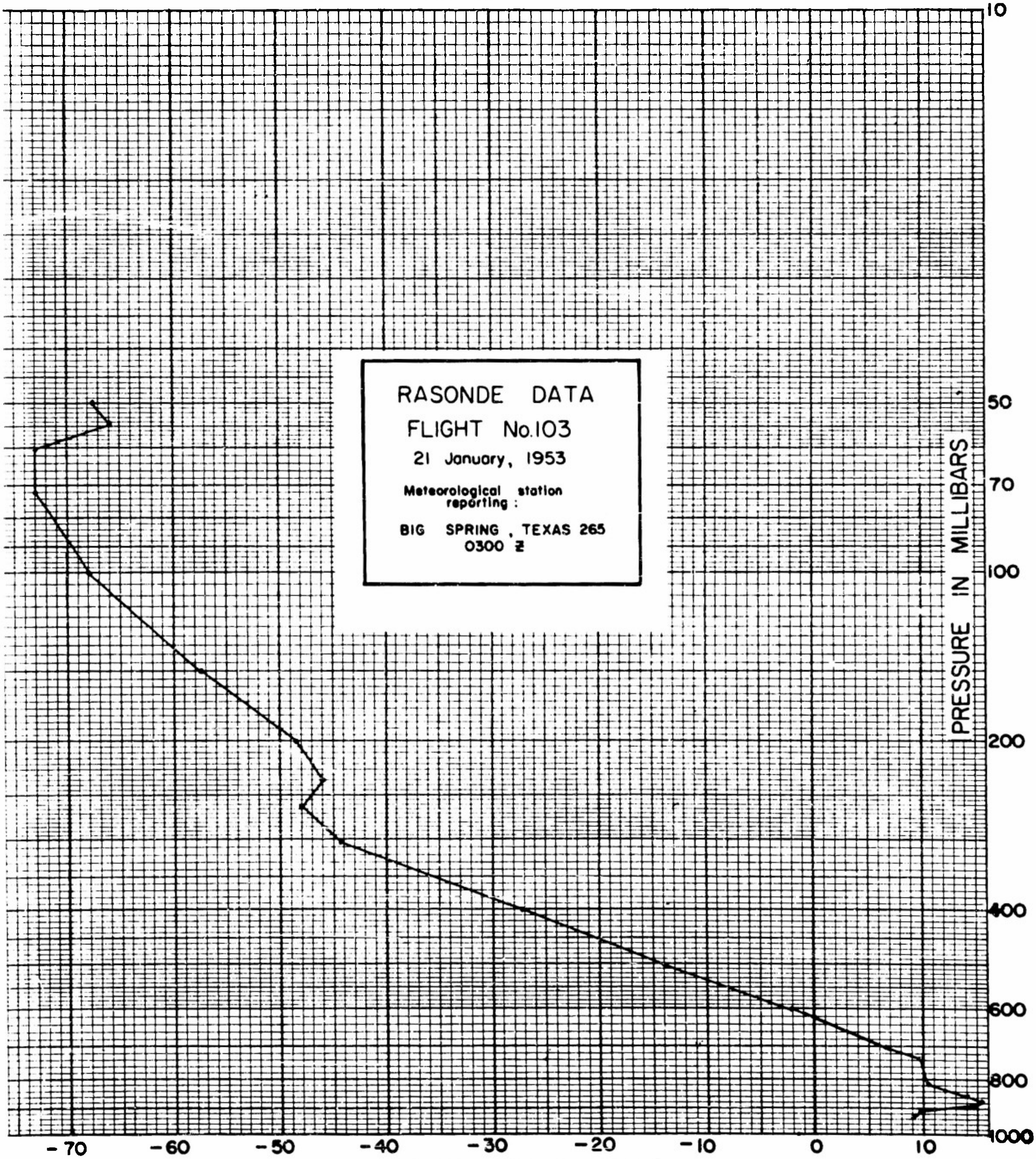
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



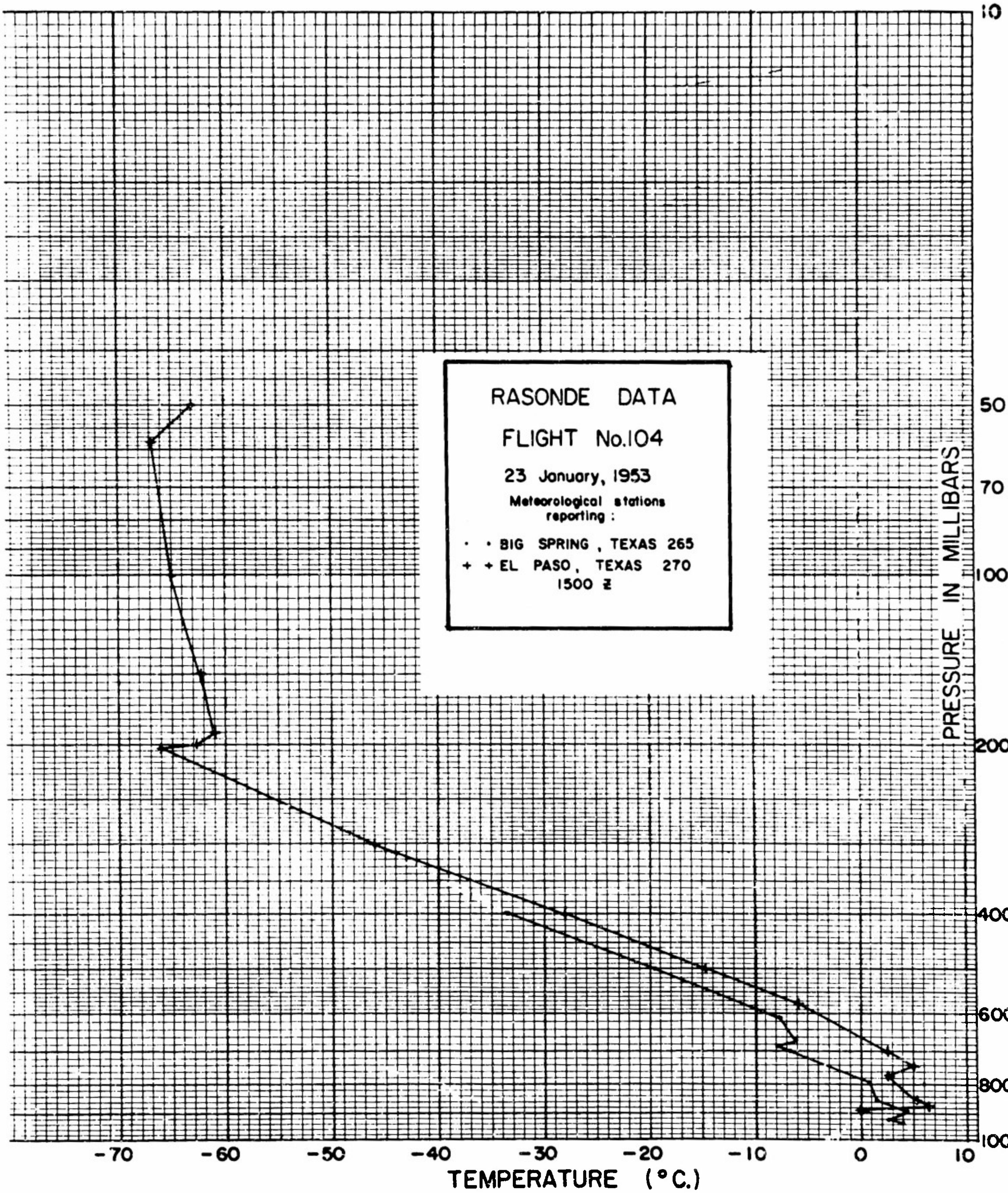
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



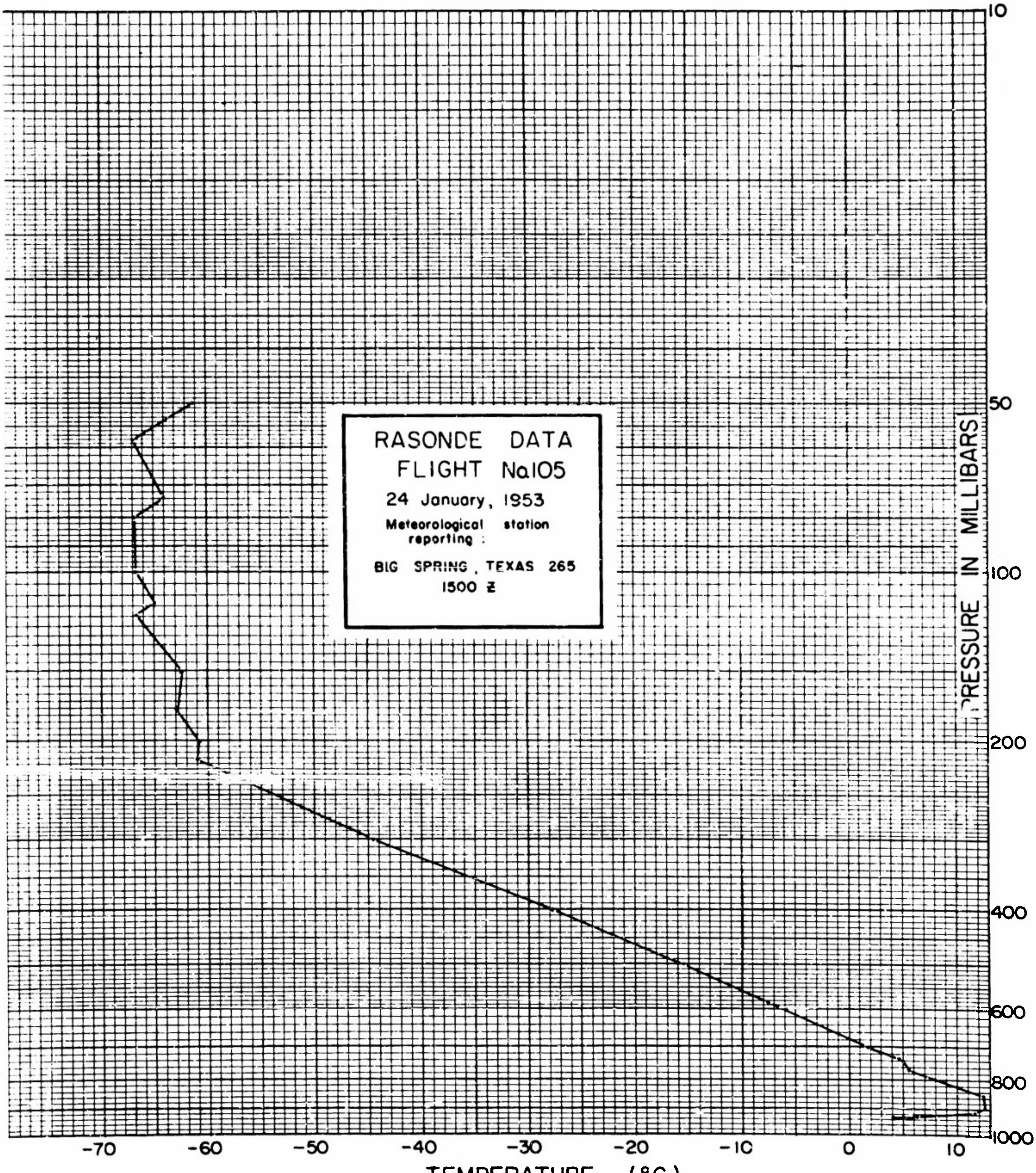
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



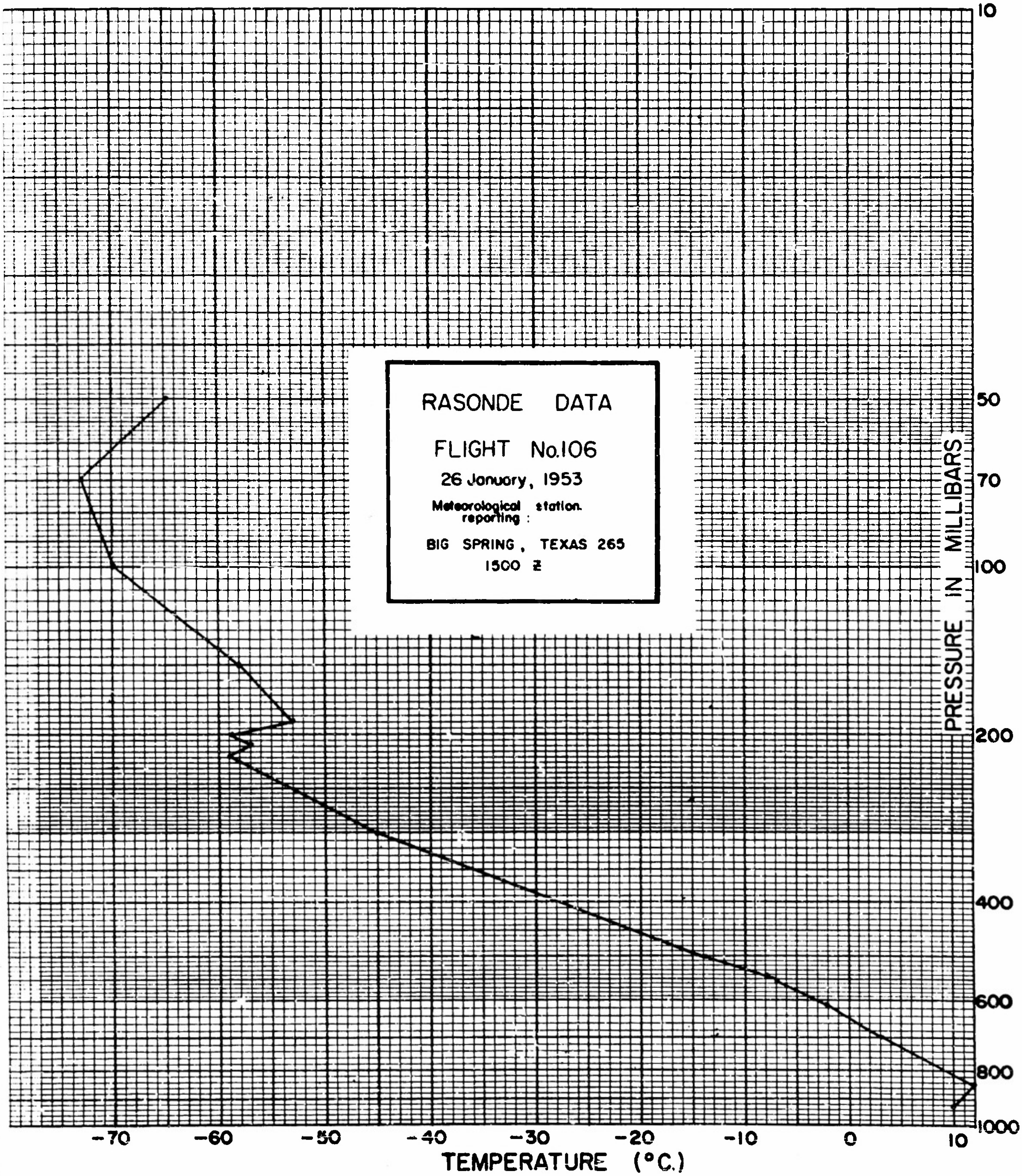
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



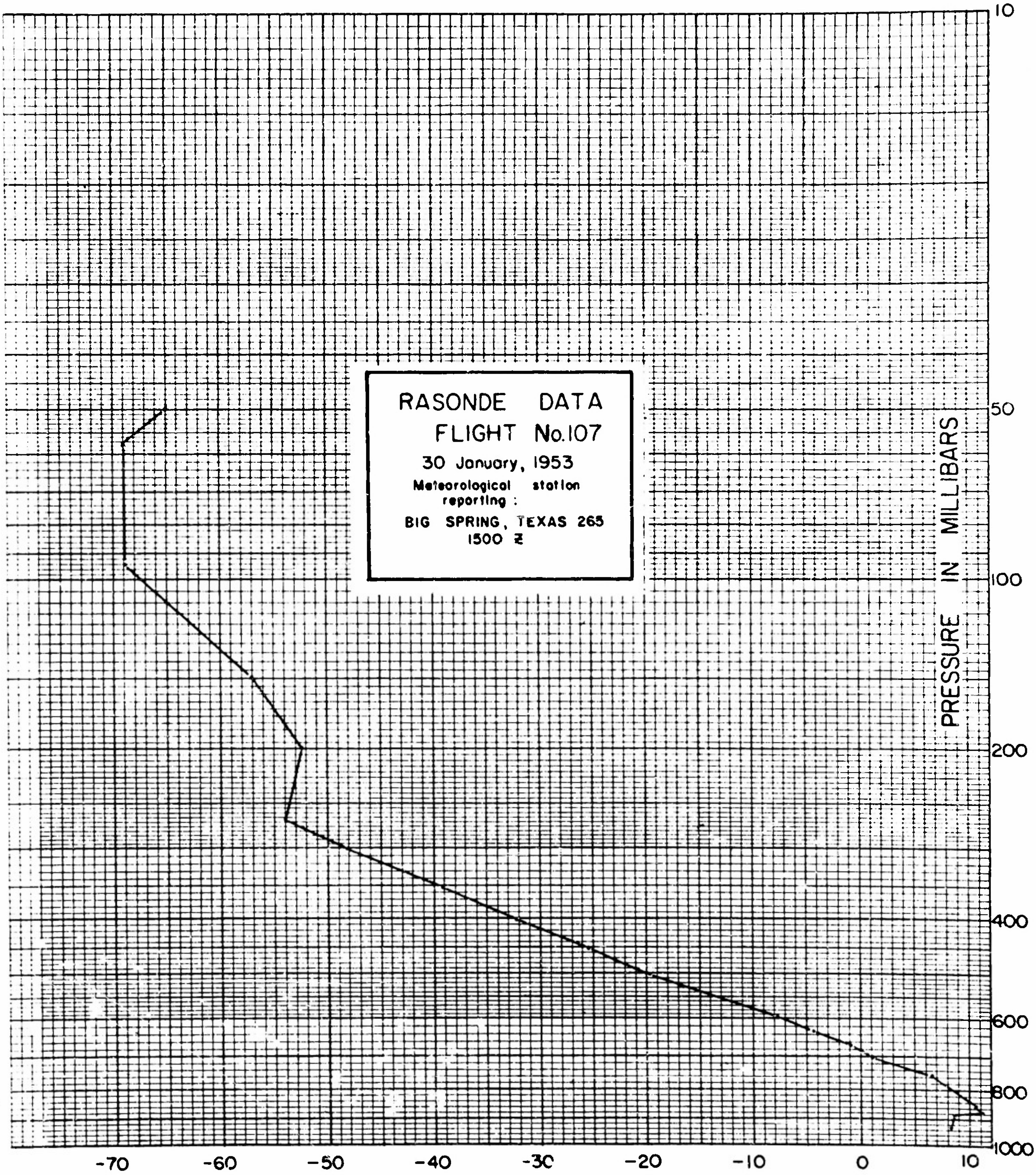
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



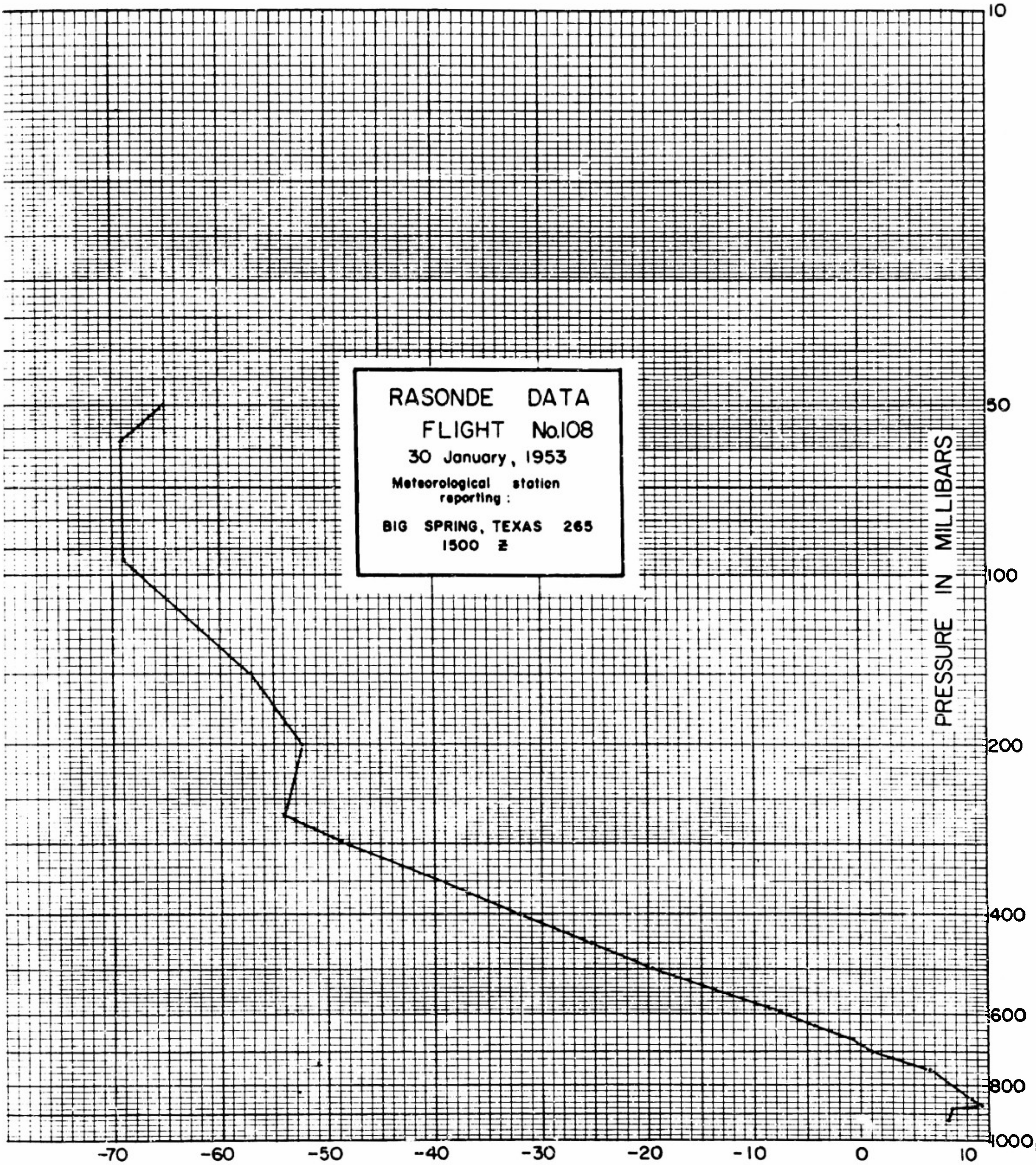
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



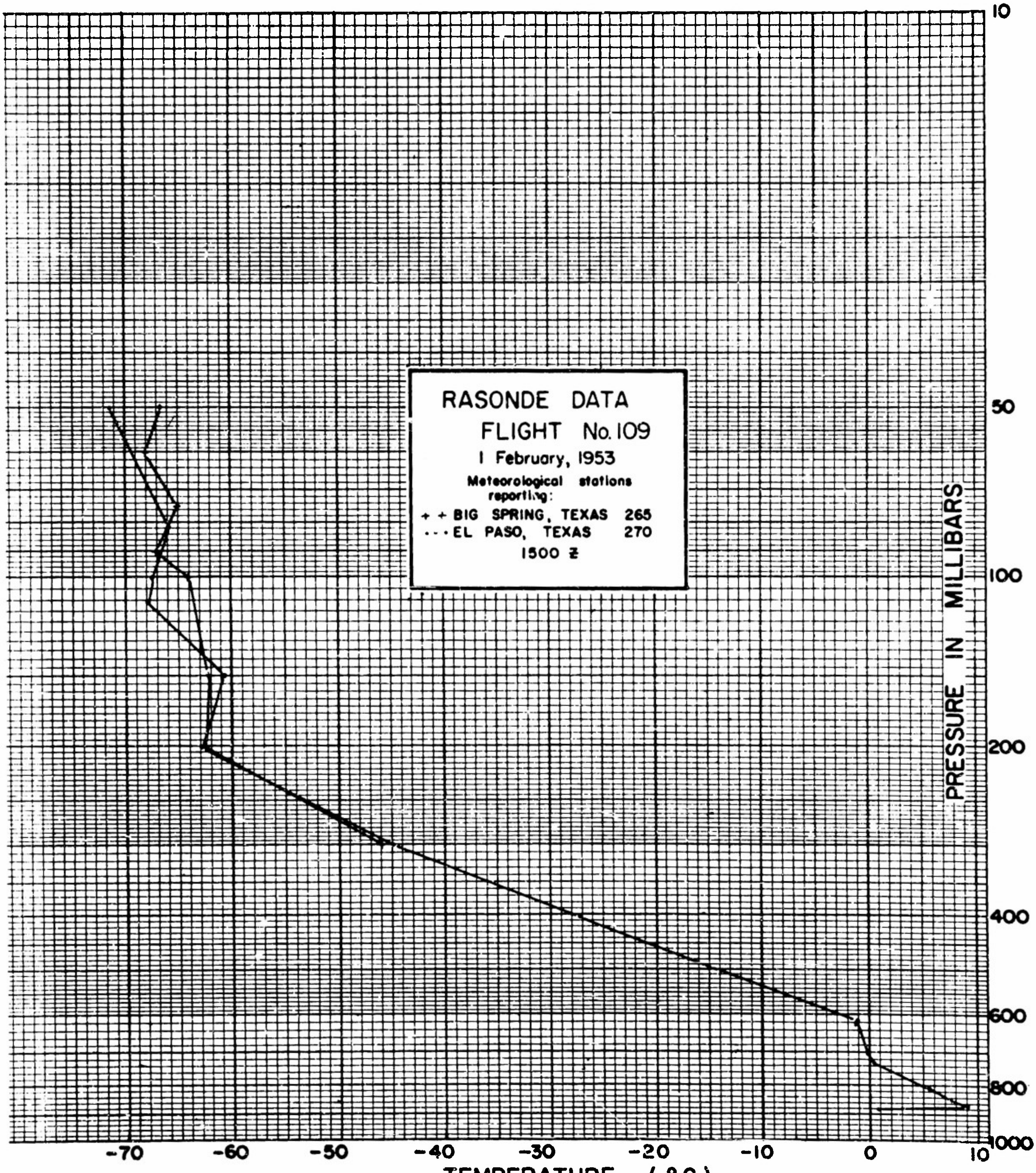
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



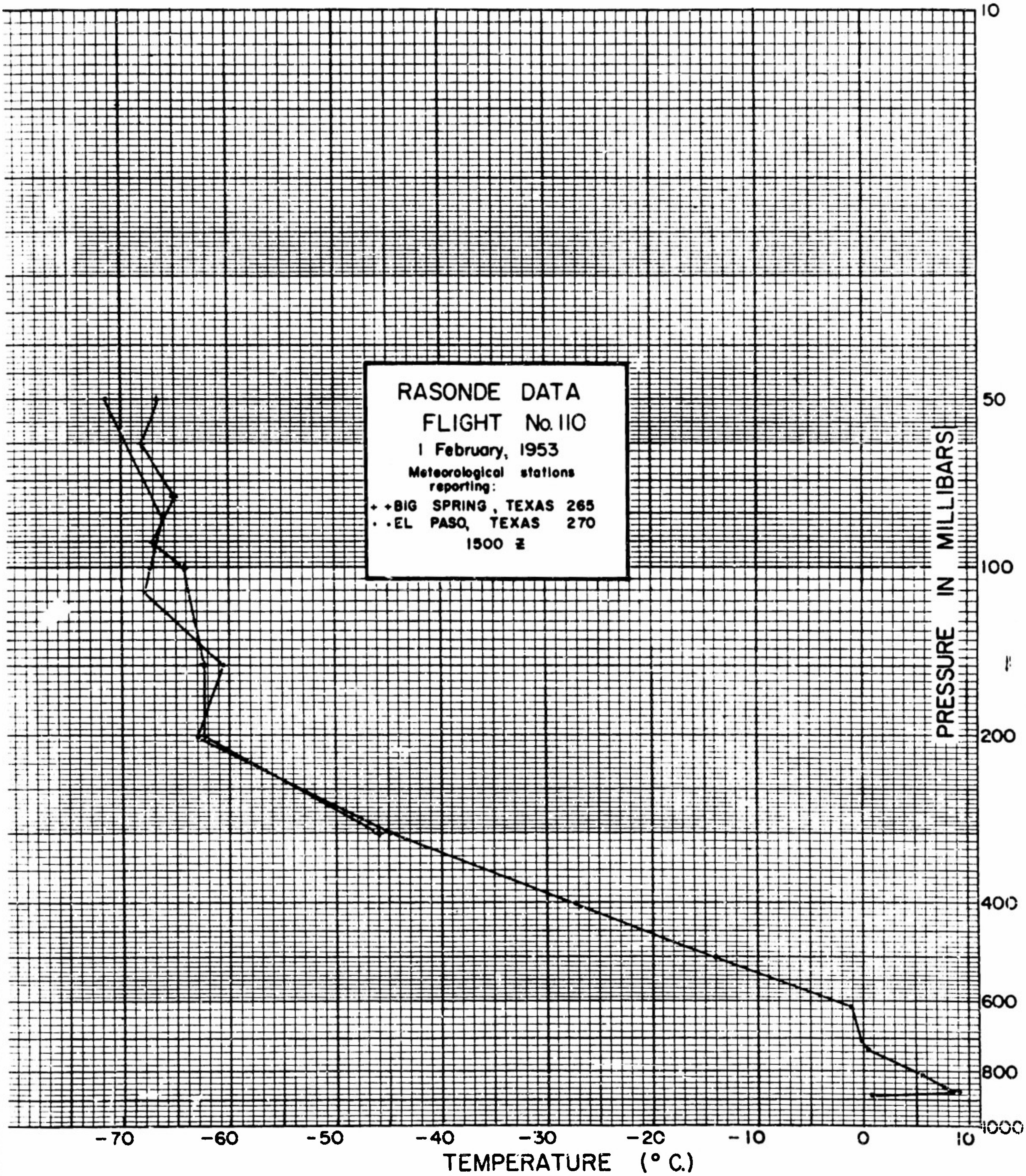
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



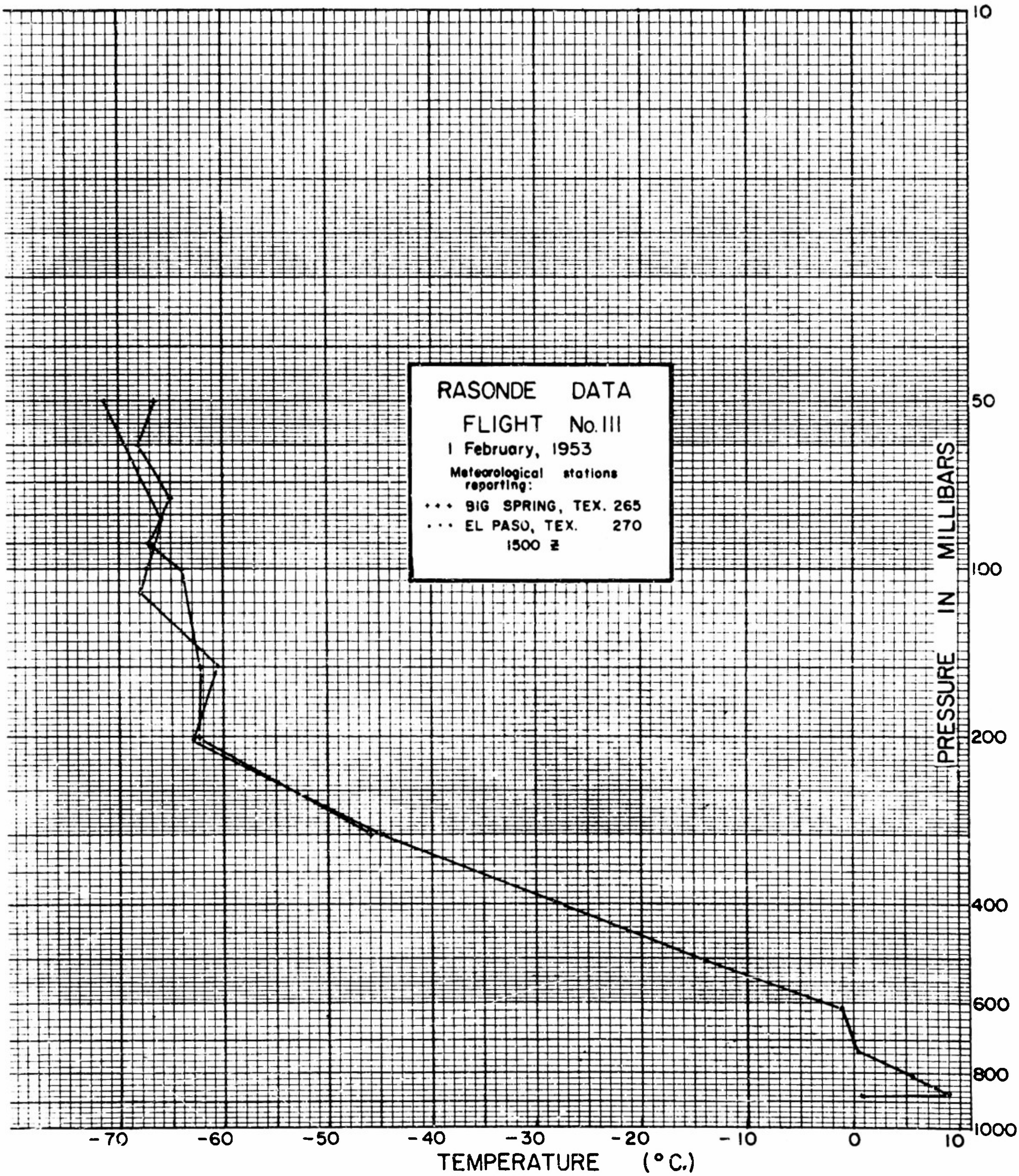
CONFIDENTIAL SECURITY INFOMATION

CONFIDENTIAL



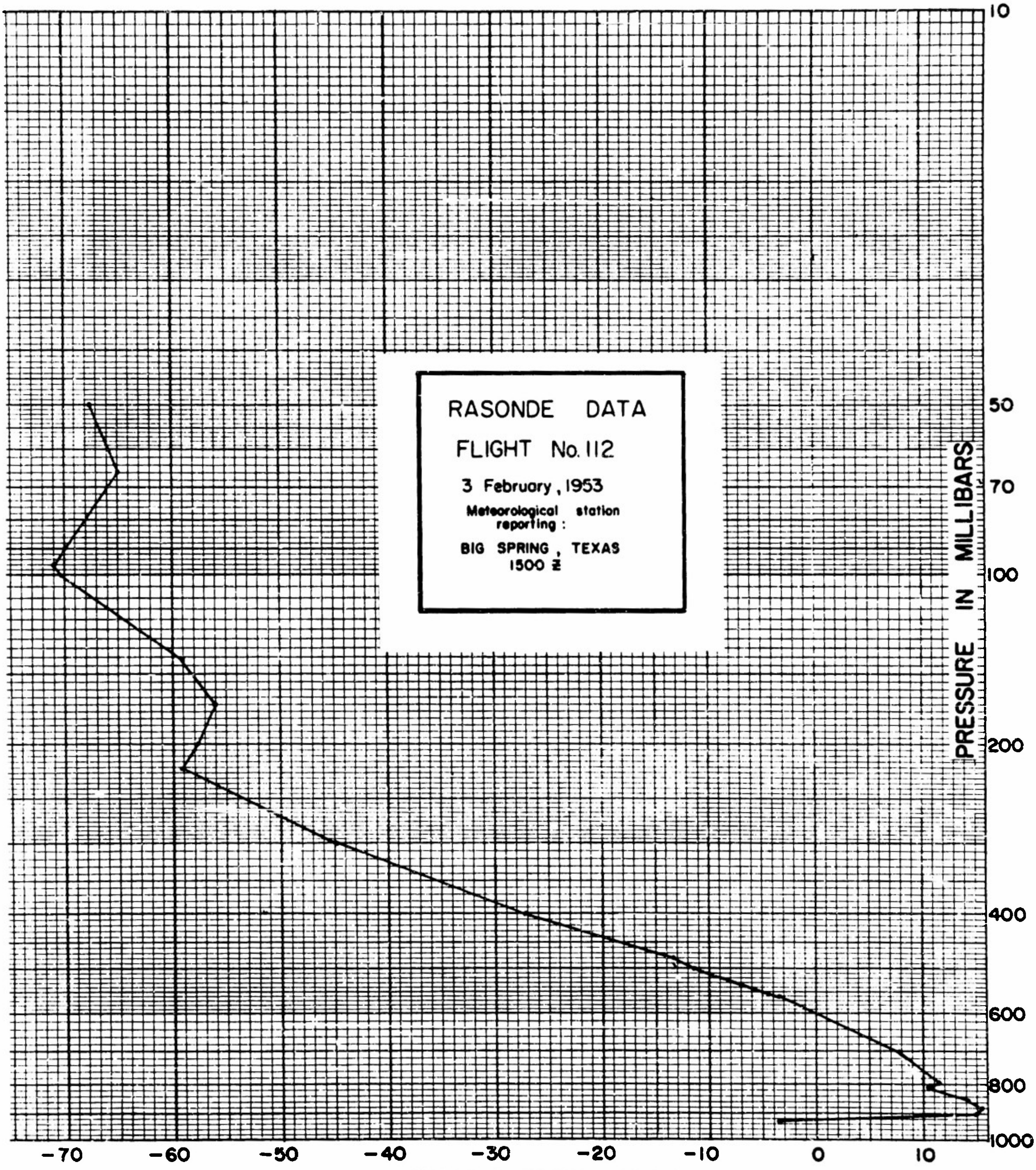
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



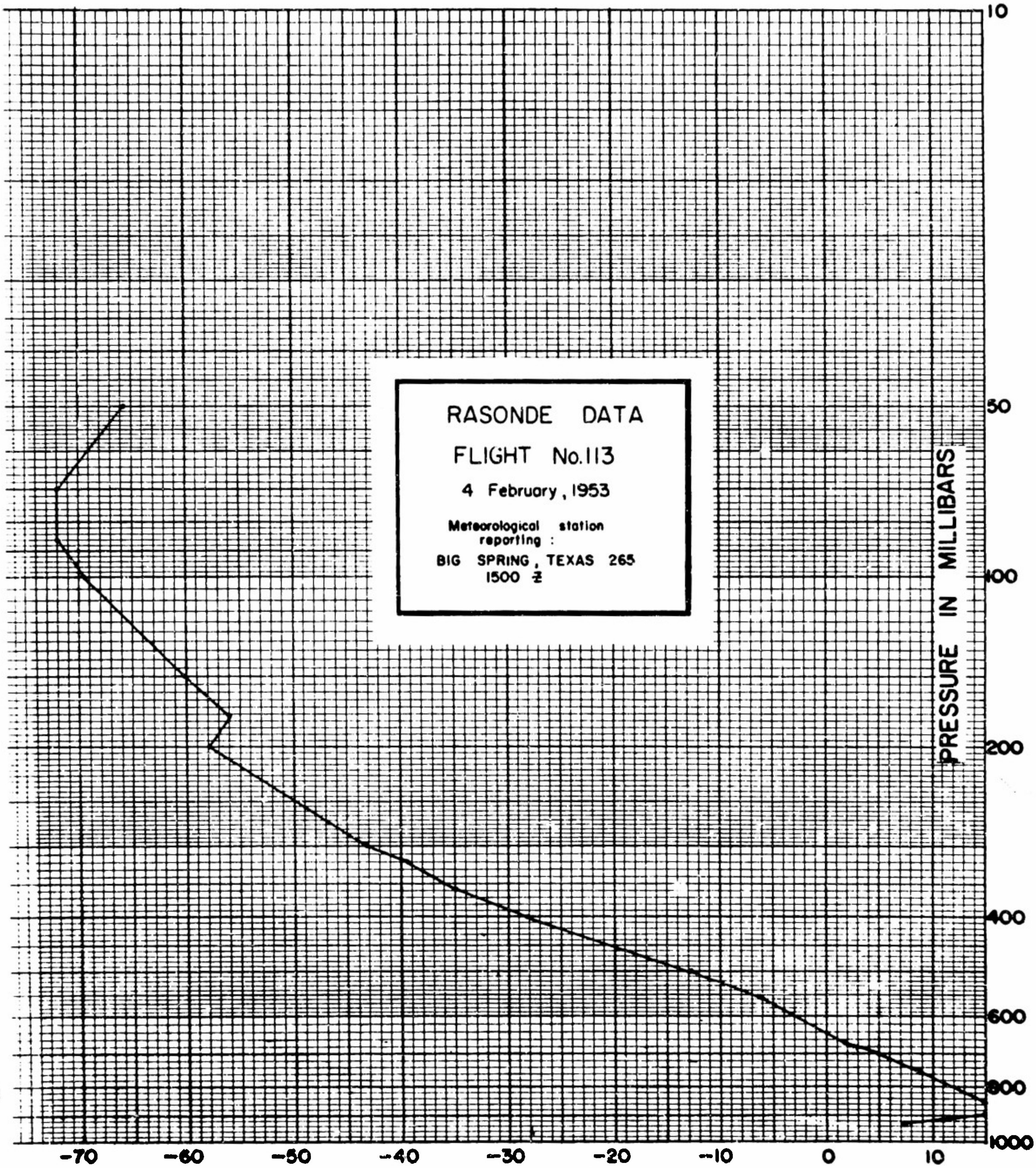
CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL



CONFIDENTIAL SECURITY INFORMATION

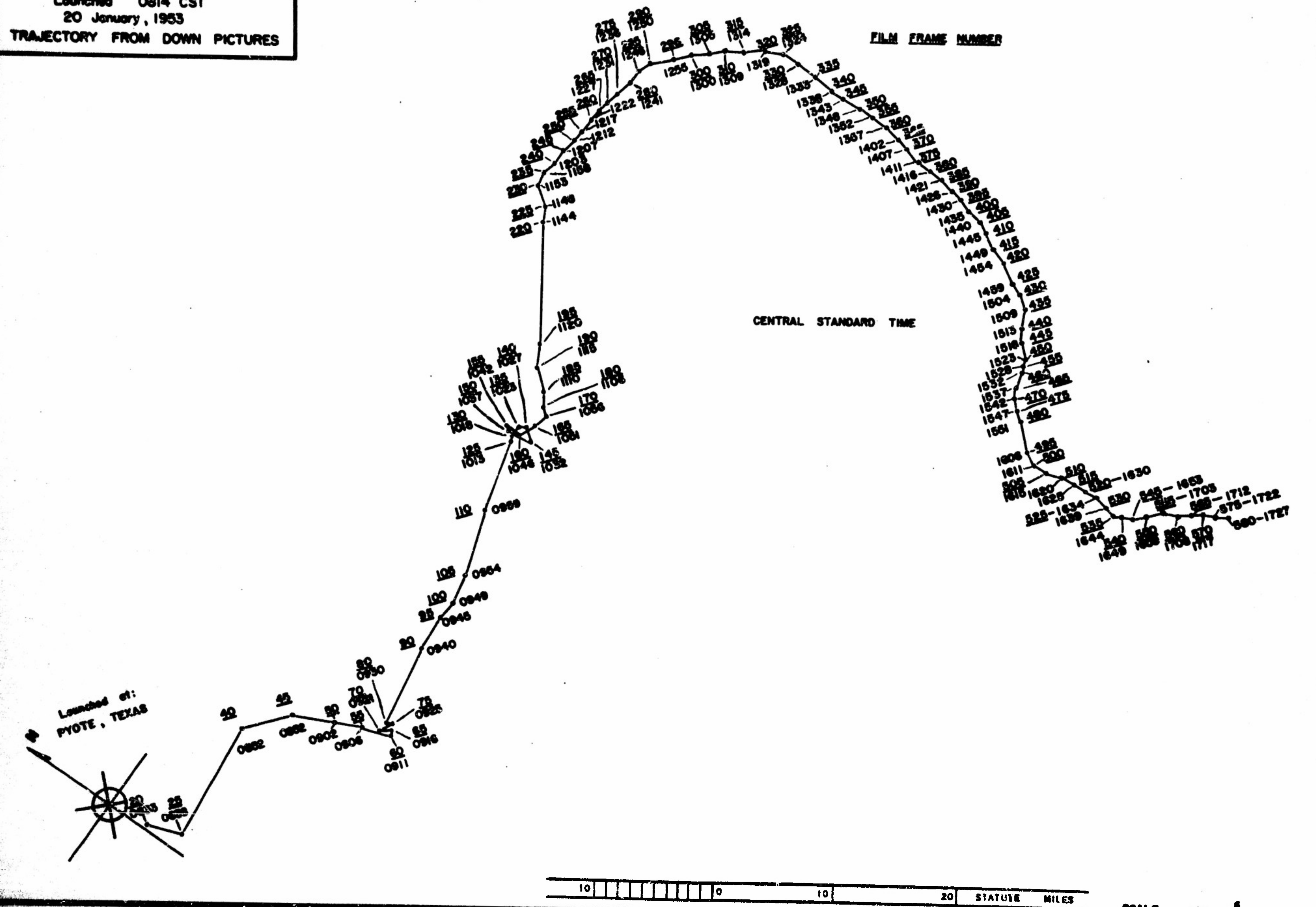
CONFIDENTIAL



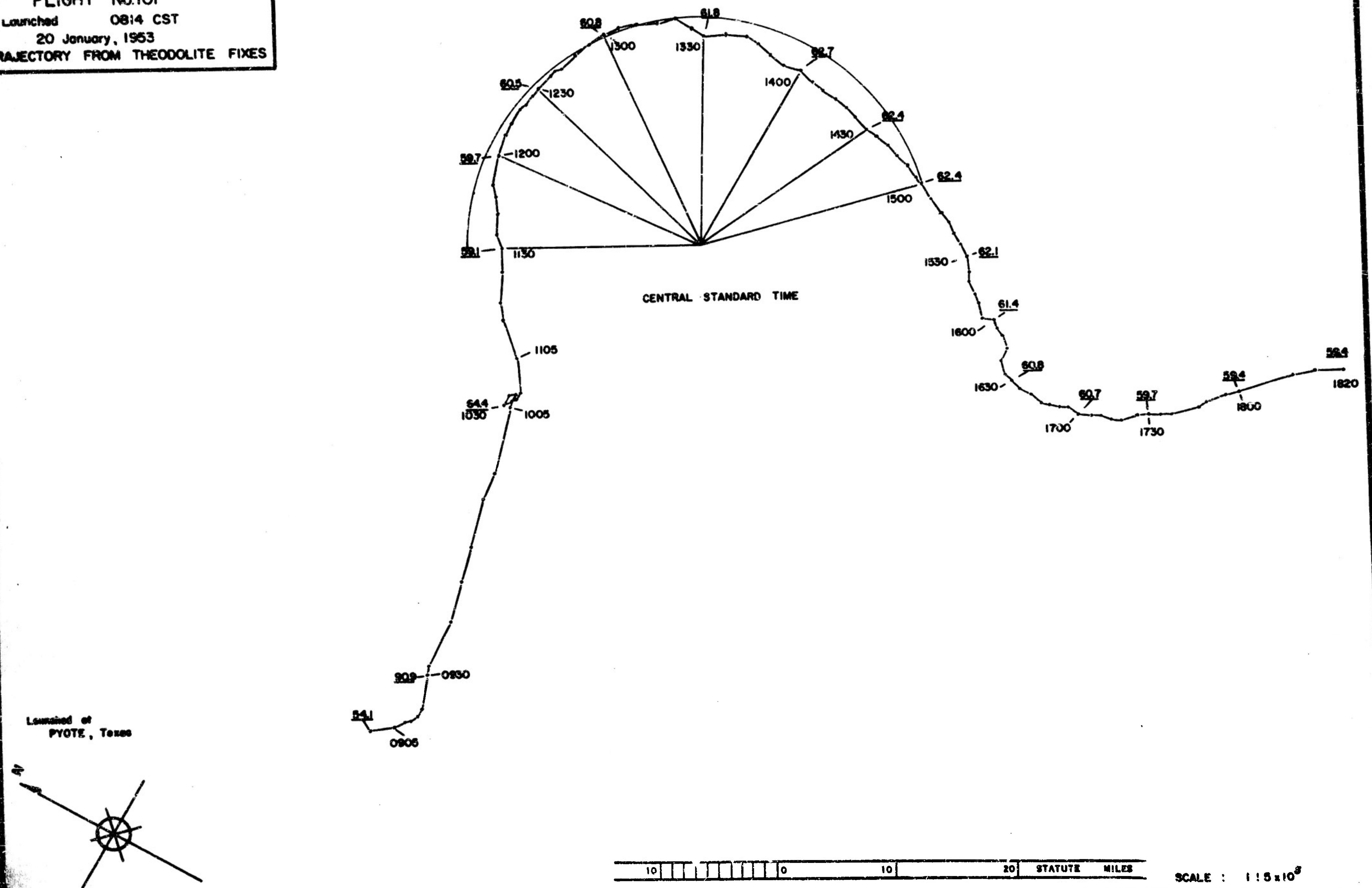
TEMPERATURE (° C.)

CONFIDENTIAL SECURITY INFORMATION

FLIGHT No. 101
Launched 0814 CST
20 January, 1953
TRAJECTORY FROM DOWN PICTURES

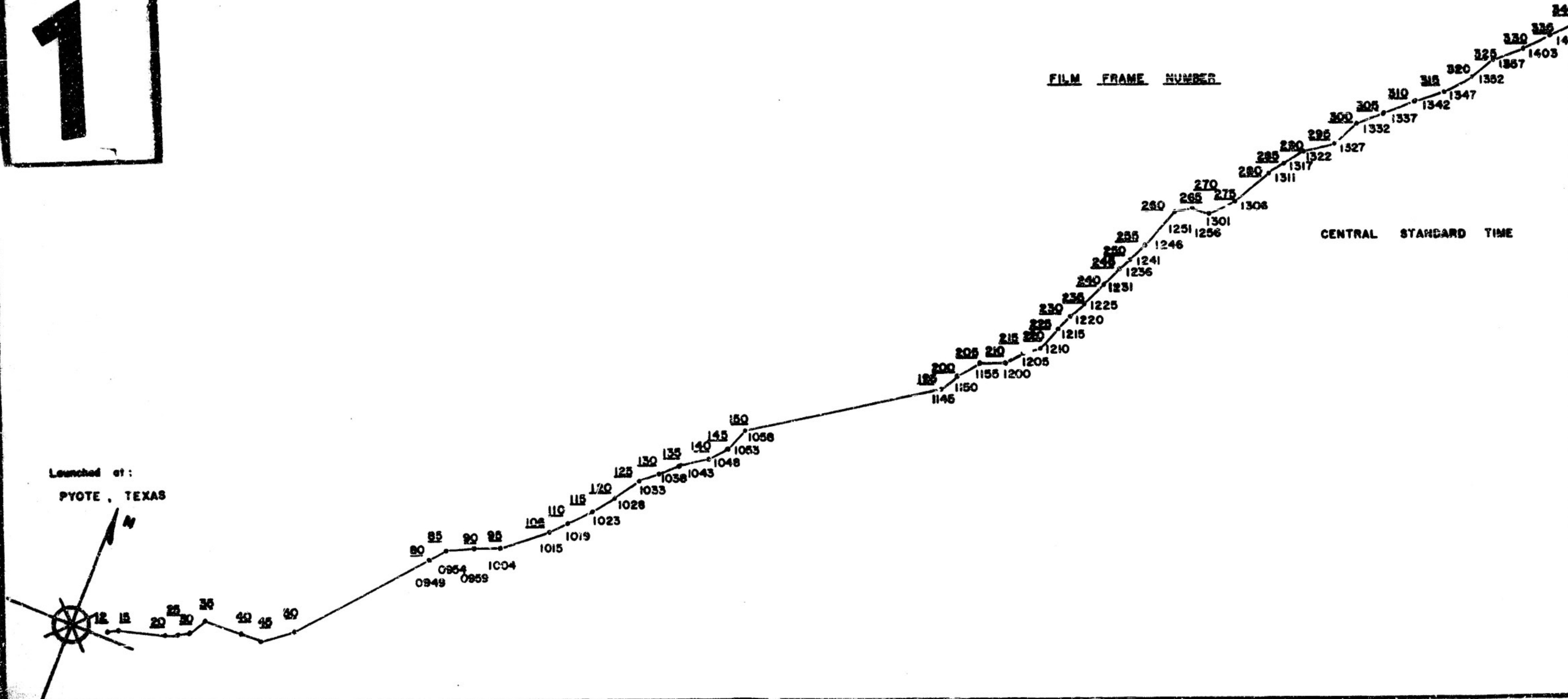


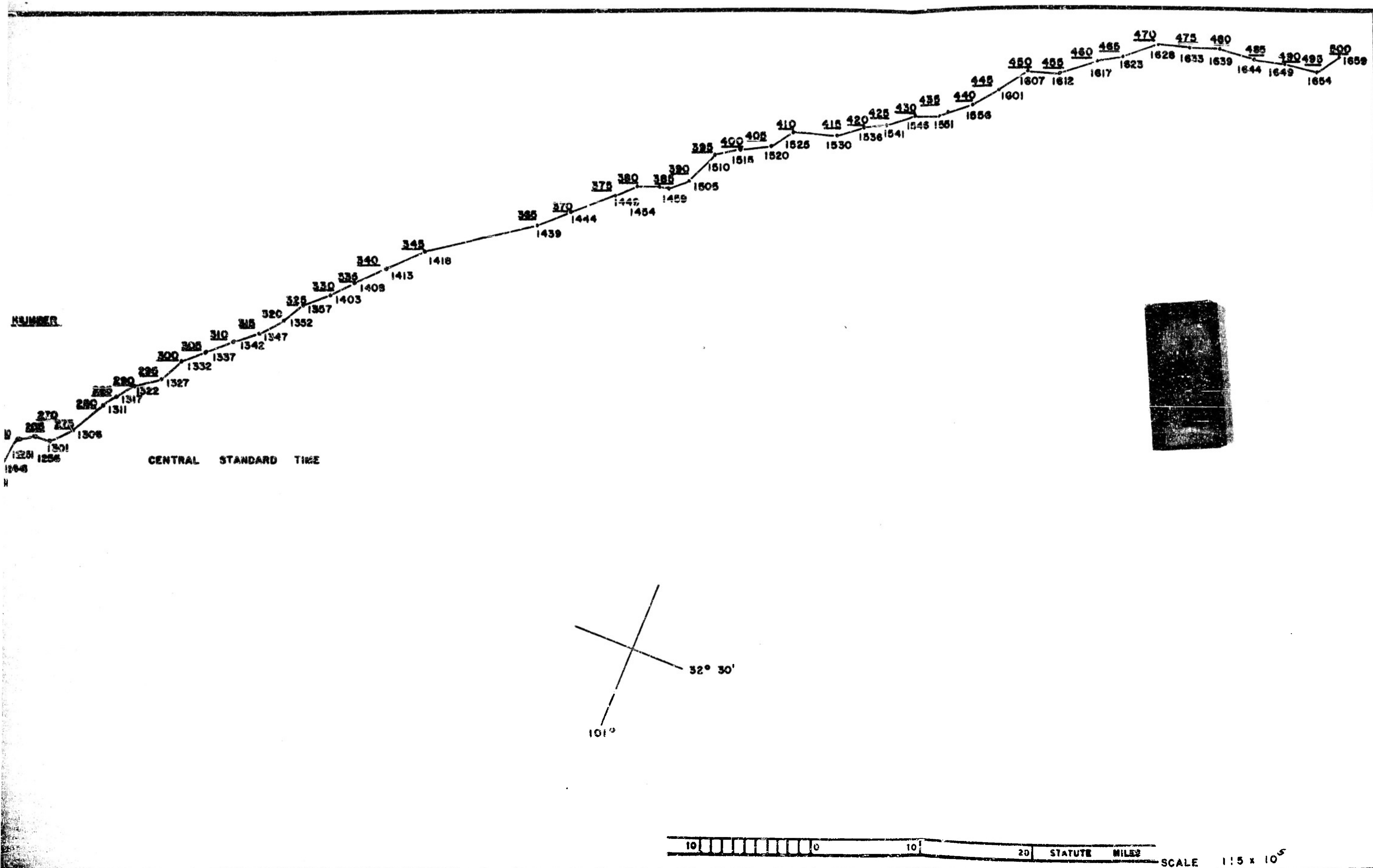
FLIGHT No. 101
Launched 0814 CST
20 January, 1953
TRAJECTORY FROM THEODOLITE FIXES



FLIGHT No. 103
Launched 0832 C.S.T.
21 January, 1953
TRAJECTORY FROM DOWN PICTURES

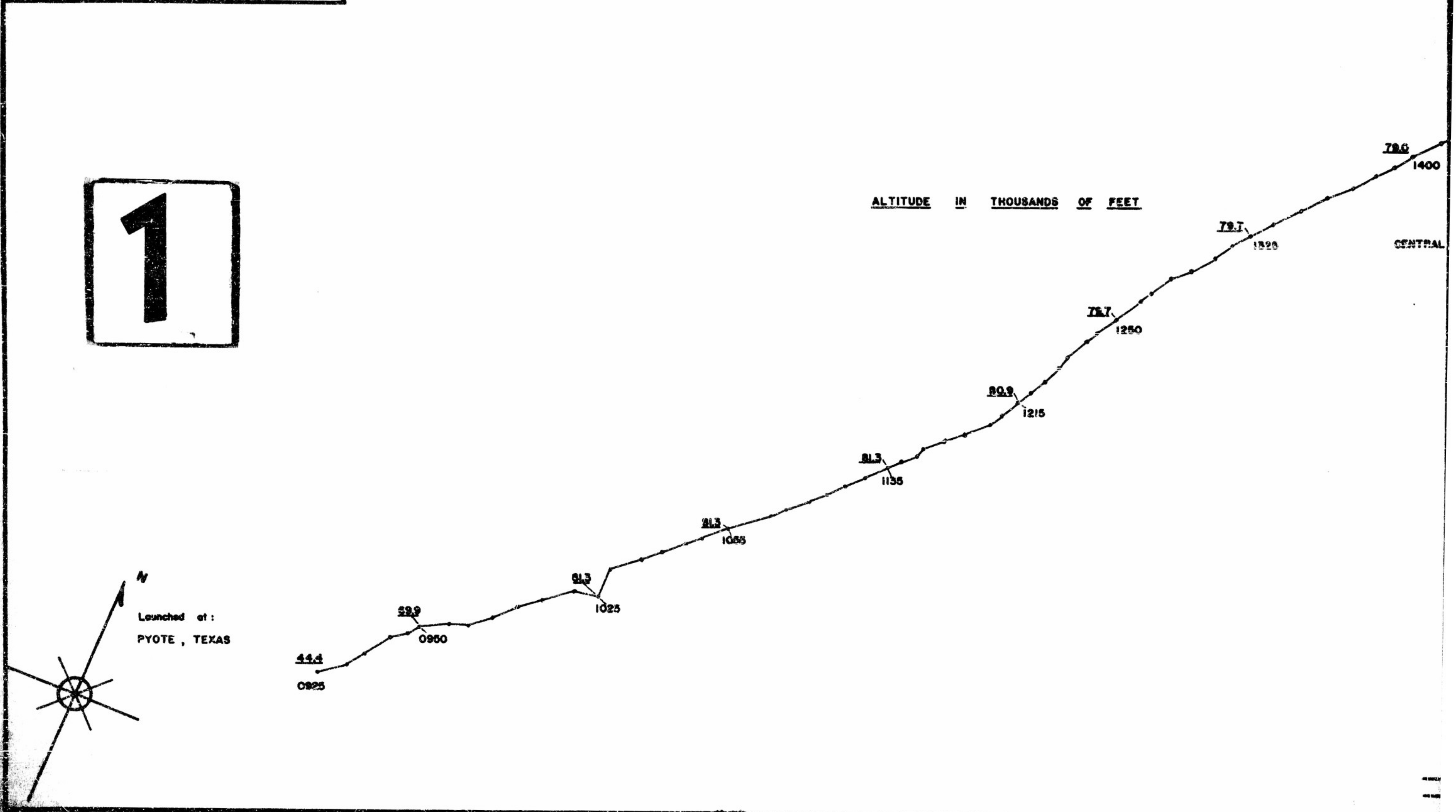
1

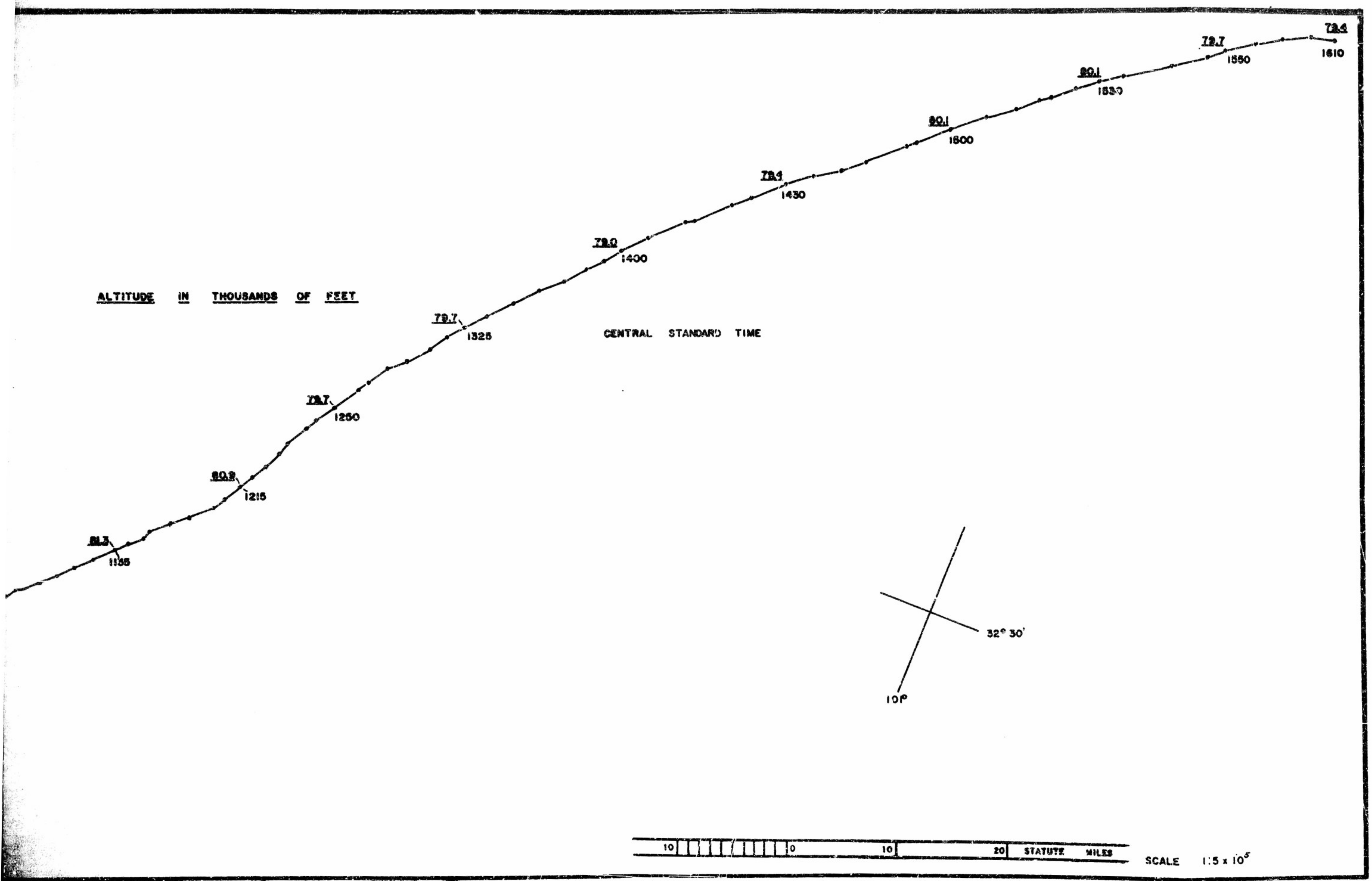


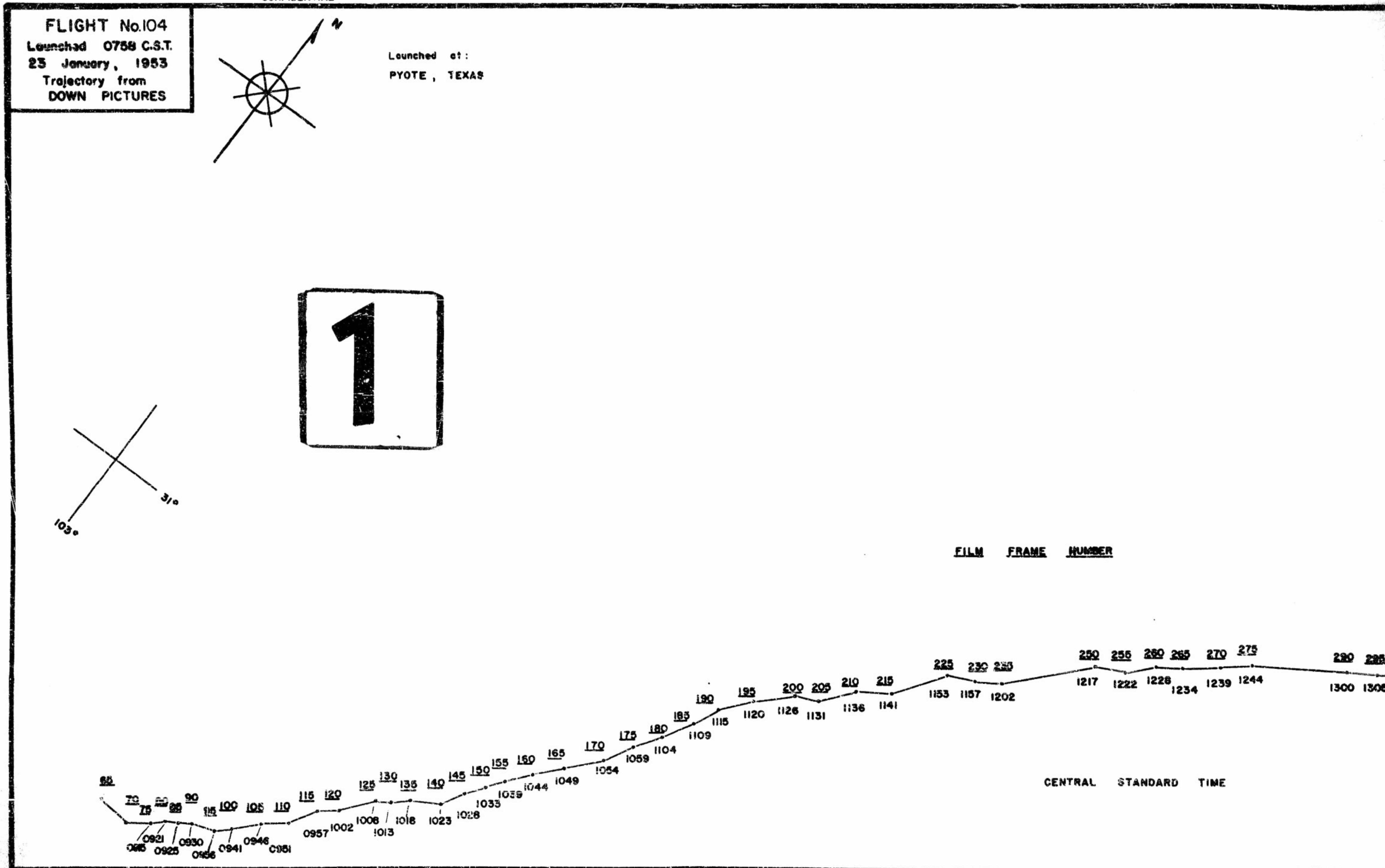


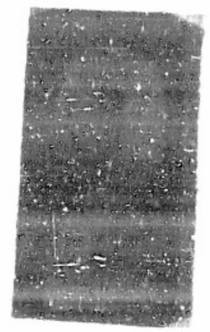
NUMBER
CENTRAL STANDARD TIME
270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500
1246 1251 1256 1301 1306 1311 1317 1322 1327 1332 1337 1342 1347 1352 1357 1403 1408 1413 1418 1439 1444 1449 1454 1459 1505 1510 1515 1520 1525 1530 1536 1541 1546 1551 1556 1601 1607 1612 1617 1623 1628 1633 1639 1644 1649 1654 1659
32° 30'
101°
10 0 10 20 STATUTE MILES
SCALE 1:5 x 10^5

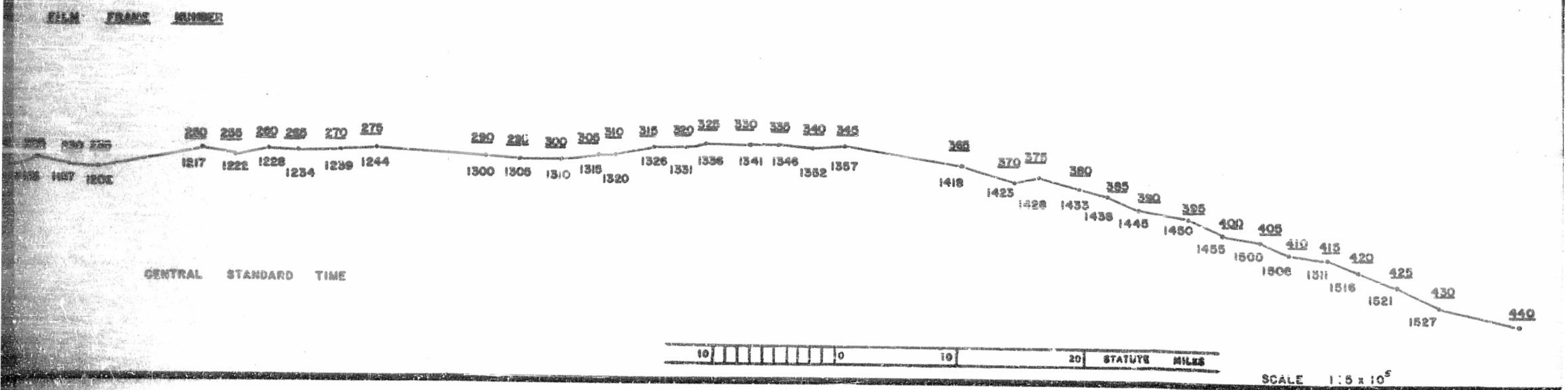
FLIGHT No.103
Launched 0832 C.S.T.
21 January, 1953
TRAJECTORY FROM THEODOLITE FIXES

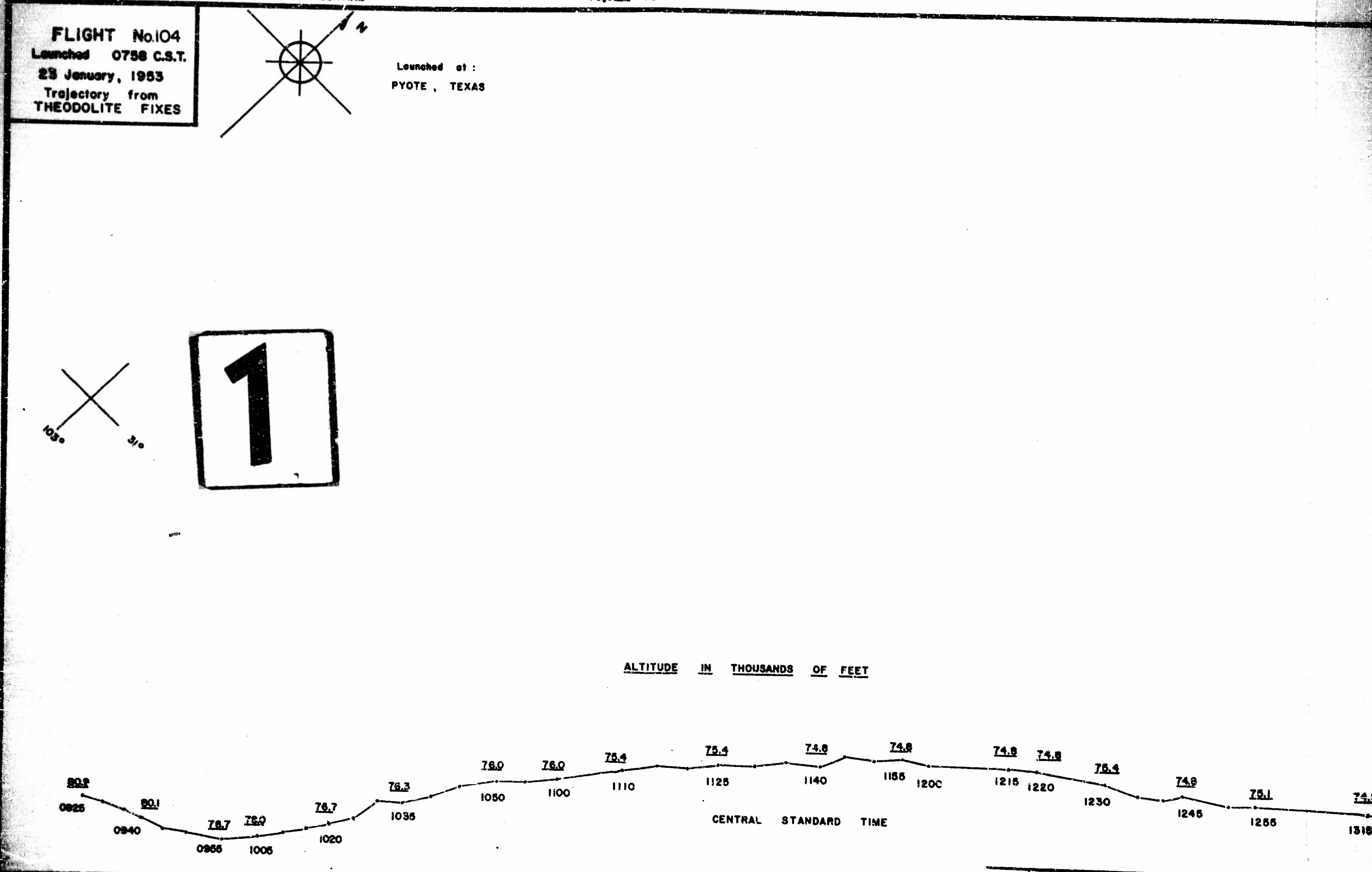



ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
81.3
1135
80.9
1215
79.7
1250
79.7
1325
79.0
1400
79.4
1430
80.1
1500
80.1
1530
79.7
1550
79.4
1610
32° 30'
101°
10
0
10
20
STATUTE MILES
SCALE 1:5 x 10^5


FLIGHT No.104
Launched 0758 C.S.T.
23 January, 1953
Trajectory from
DOWN PICTURES
N
Launched at:
PYOTE, TEXAS
1
31°
103°
FILM FRAME NUMBER
CENTRAL STANDARD TIME



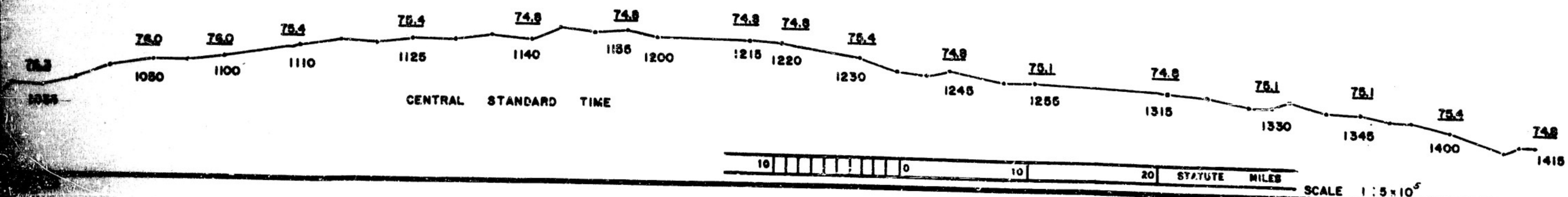

FILM FRAME NUMBER
250 255 260 265 270 275
1217 1222 1228 1234 1239 1244
290 295 300 305 310 315 320 325 330 335 340 345
1300 1305 1310 1315 1320 1326 1331 1336 1341 1346 1352 1357
365 370 375 380 385 390 395 400 405 410 415 420 425 430 440
1418 1423 1428 1433 1438 1445 1450 1455 1500 1506 1511 1516 1521 1527
CENTRAL STANDARD TIME
10 0 10 20 STATUTE MILES
SCALE 1:5 x 10^5

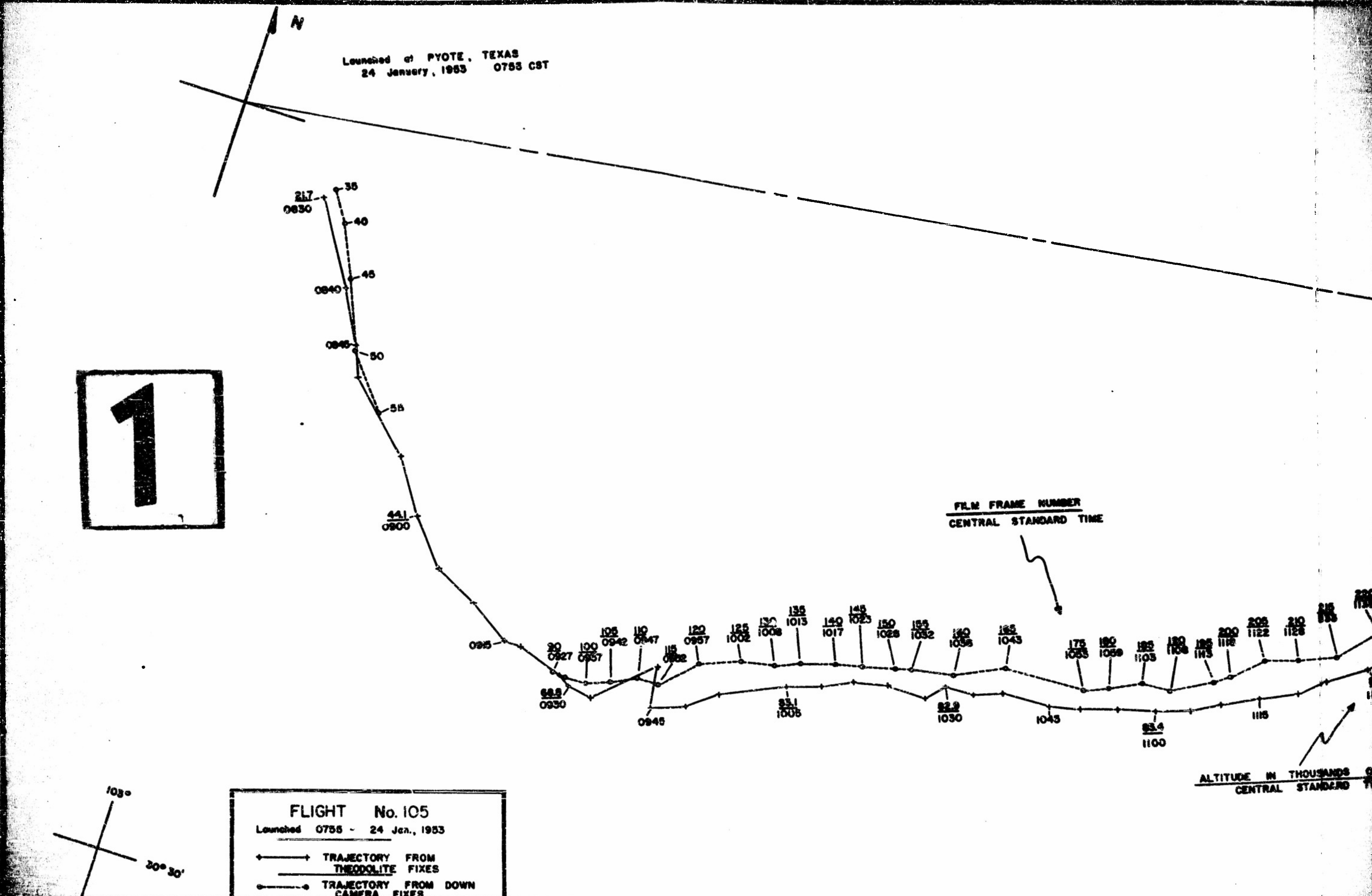

FLIGHT No.104
Launched 0758 C.S.T.
23 January, 1953
Trajectory from
THEODOLITE FIXES
N
Launched at :
PYOTE , TEXAS
1
103°
31°
ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
80.1
76.3
76.0
76.0
75.4
75.4
74.8
75.4
75.1
0925
0940
0955
1005
1020
1035
1050
1100
1110
1125
1140
1155
1200
1215
1220
1230
1245
1255
1315
10
0
10
20

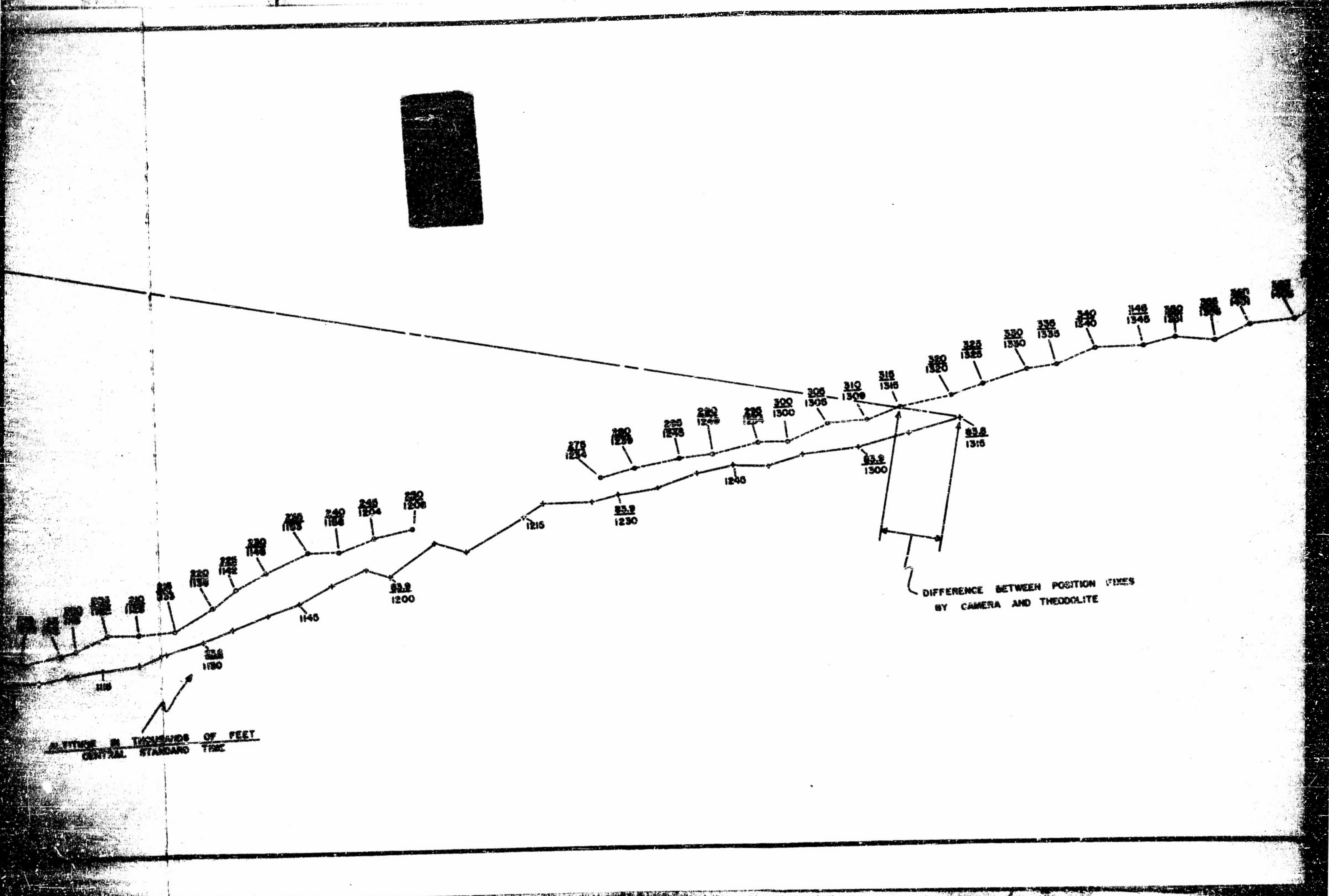
Launched at :
PYOTE , TEXAS

[redacted]

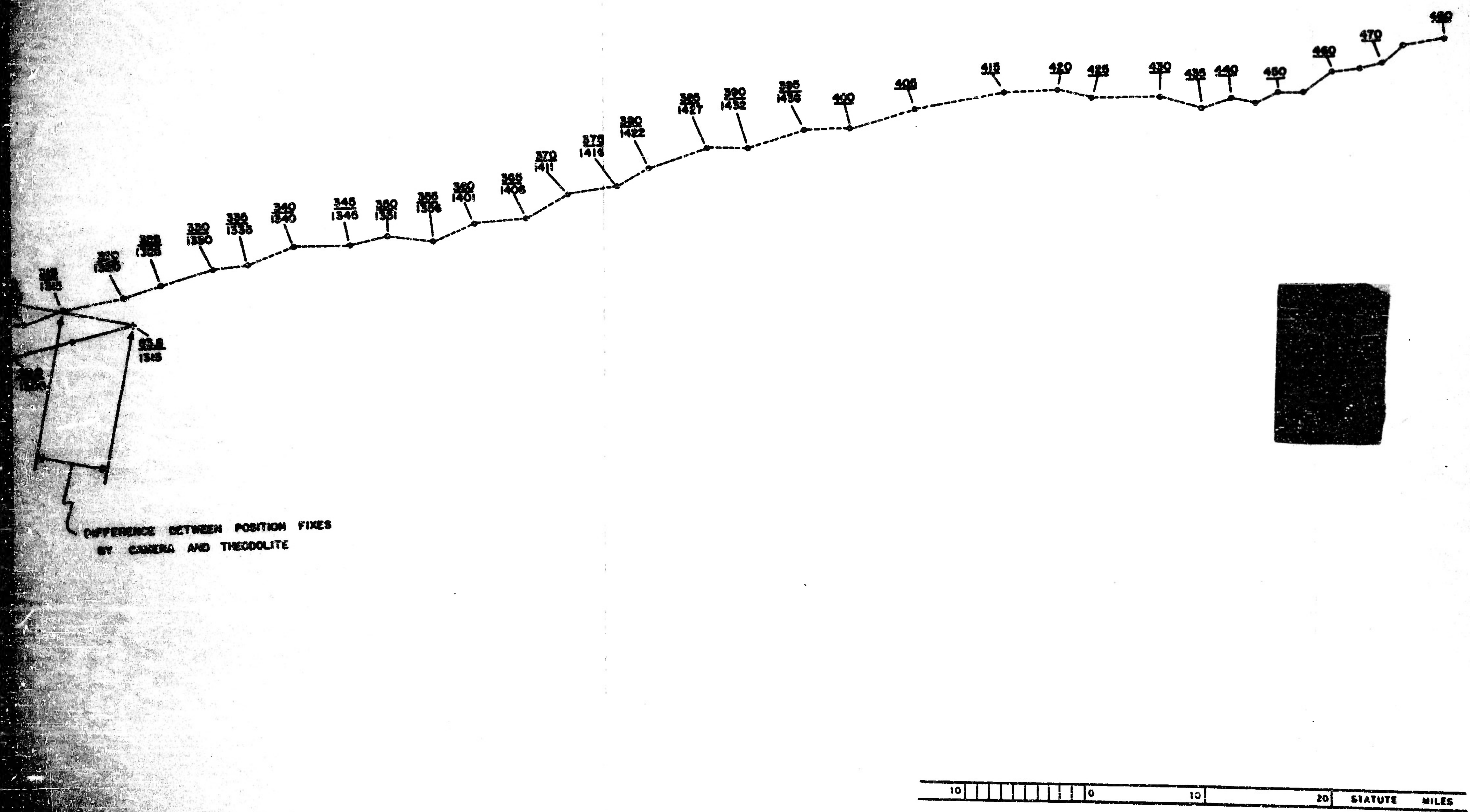
ALTITUDE IN THOUSANDS OF FEET




N
Launched at PYOTE, TEXAS
24 January, 1953 0755 CST
1
FILM FRAME NUMBER / CENTRAL STANDARD TIME
ALTITUDE IN THOUSANDS OF FEET / CENTRAL STANDARD TIME
21.7 / 0830
0840
0845
44.1 / 0900
0915
68.8 / 0930
0945
83.1 / 1005
82.9 / 1030
1045
83.4 / 1100
1115
35
40
45
50
55
90 / 0927
100 / 0937
105 / 0942
110 / 0947
115 / 0952
120 / 0957
125 / 1002
130 / 1008
135 / 1013
140 / 1017
145 / 1023
150 / 1028
155 / 1032
160 / 1036
165 / 1043
175 / 1053
180 / 1059
185 / 1103
190 / 1108
195 / 1113
200 / 1118
205 / 1122
210 / 1128
103°
30° 30'
FLIGHT No. 105
Launched 0755 - 24 Jan., 1953
TRAJECTORY FROM THEODOLITE FIXES
TRAJECTORY FROM DOWN CAMERA FIXES

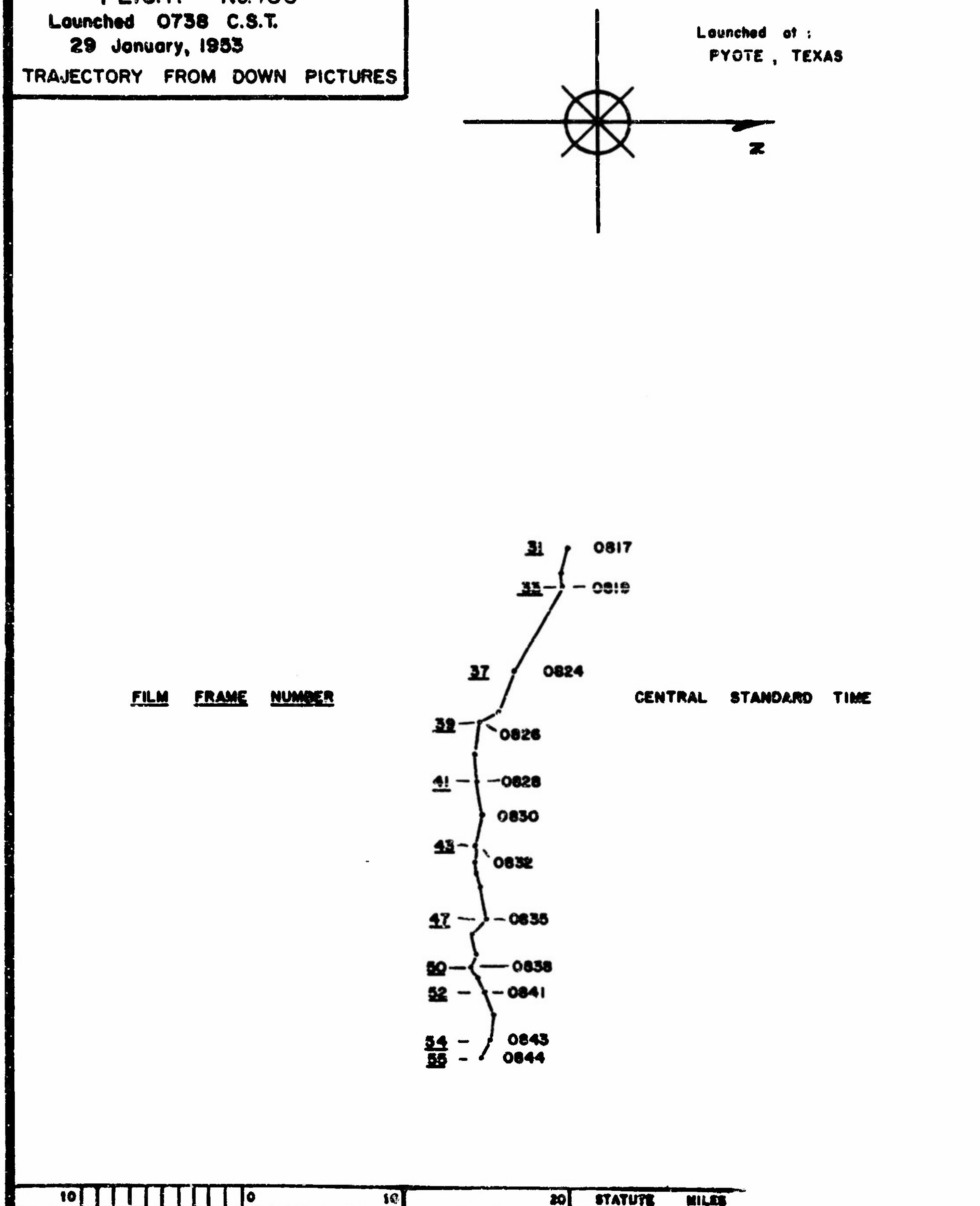


DIFFERENCE BETWEEN POSITION FIXES
BY CAMERA AND THEODOLITE
ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME

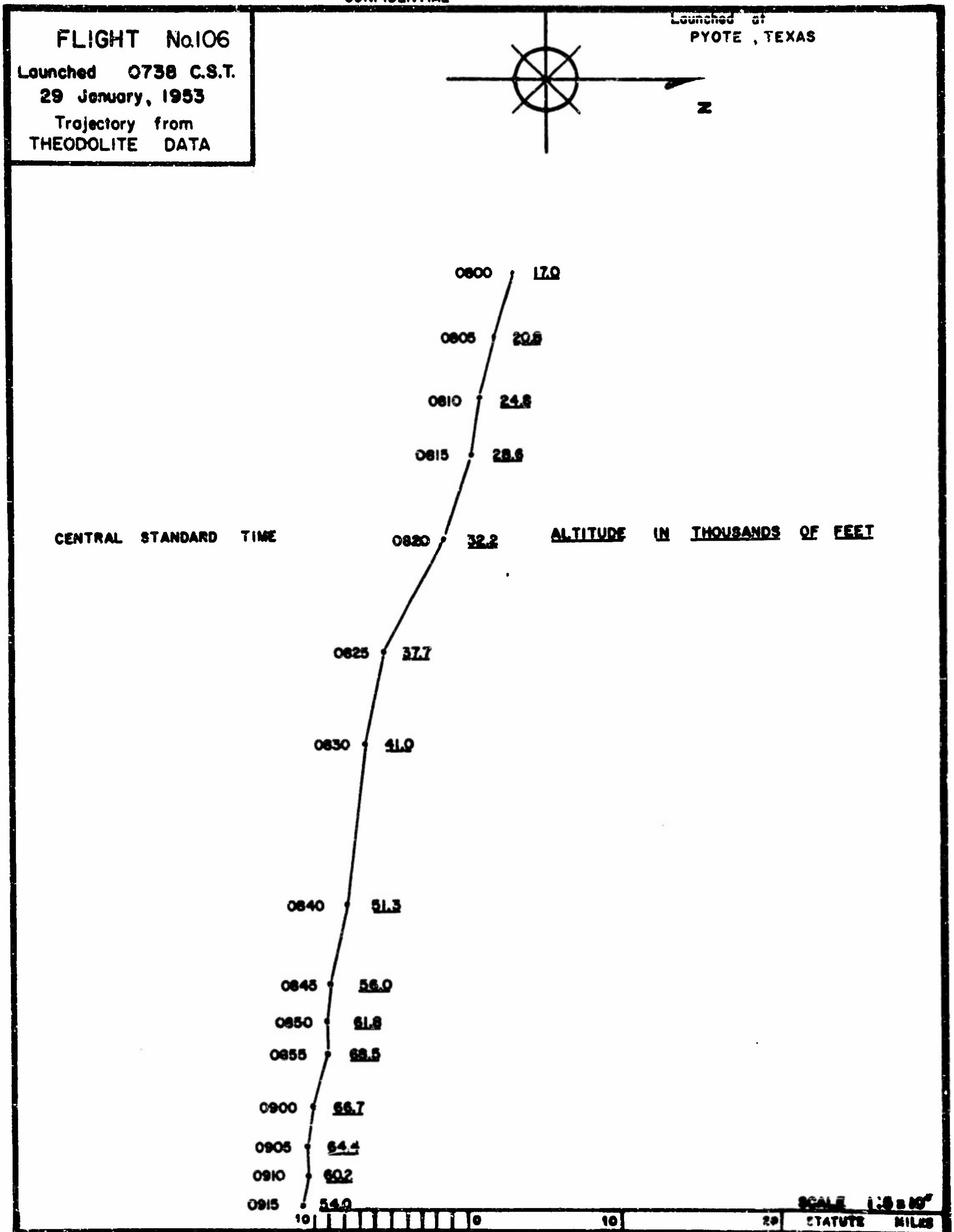


340
1340
345
1345
350
1351
355
1356
360
1401
365
1406
370
1411
375
1416
380
1422
385
1427
390
1432
395
1436
400
405
415
420
425
430
435
440
450
460
470
480
DIFFERENCE BETWEEN POSITION FIXES
BY CAMERA AND THEODOLITE
10
0
10
20
STATUTE MILES

FLIGHT No. 106
Launched 0738 C.S.T.
29 January, 1953
TRAJECTORY FROM DOWN PICTURES



SCALE 1:5 x 10^5

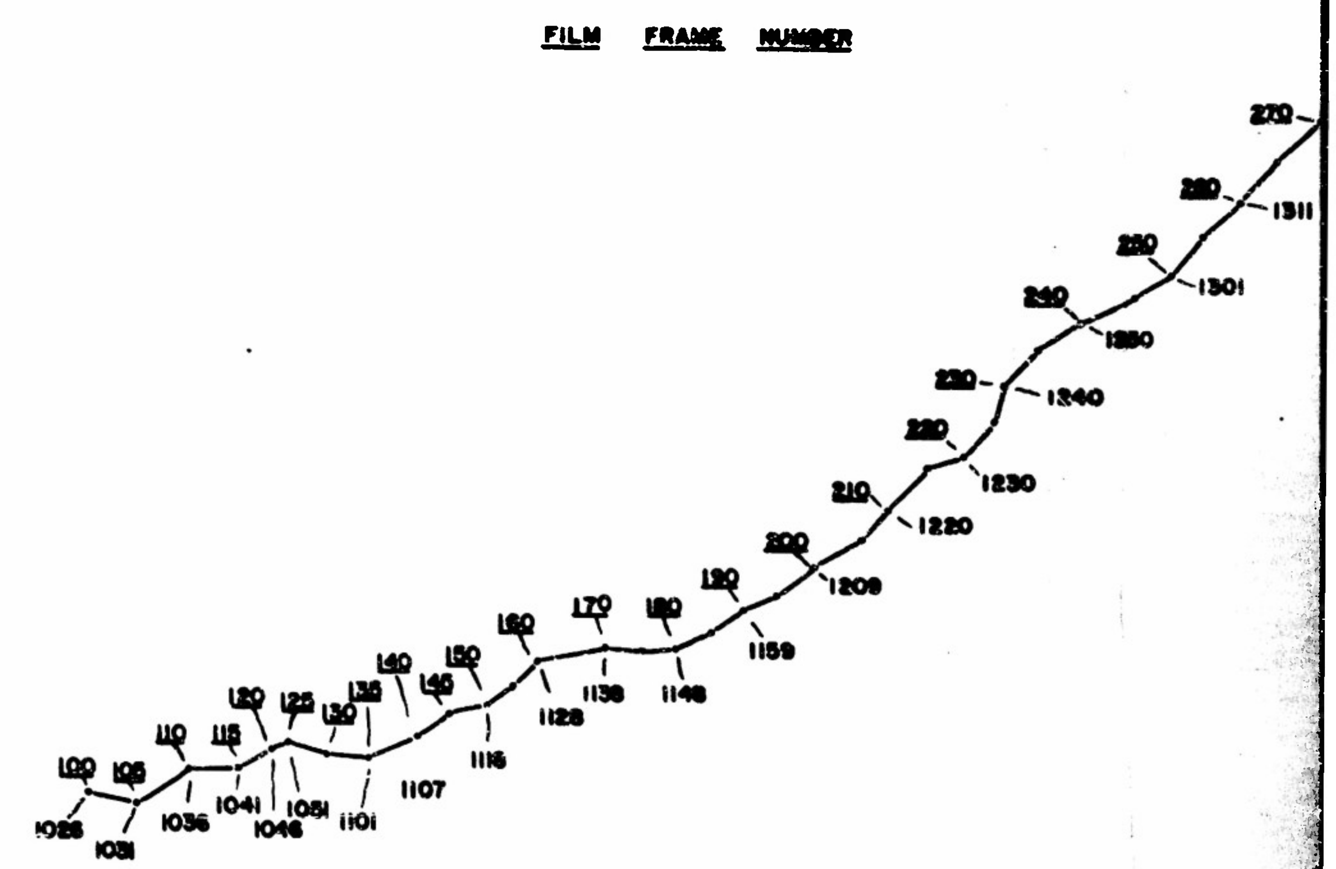

FLIGHT No.106
Launched 0738 C.S.T.
29 January, 1953
Trajectory from
THEODOLITE DATA
Launched at
PYOTE , TEXAS
N
CENTRAL STANDARD TIME
ALTITUDE IN THOUSANDS OF FEET
0800 17.0
0805 20.6
0810 24.8
0815 28.6
0820 32.2
0825 37.7
0830 41.0
0840 51.3
0845 56.0
0850 61.8
0855 68.5
0900 66.7
0905 64.4
0910 60.2
0915 54.0
SCALE
10 0 10 20 STATUTE MILES

FLIGHT No. 107

Launched 0845 C.S.T.
30 January, 1953

TRAJECTORY FROM DOWN PICTURES

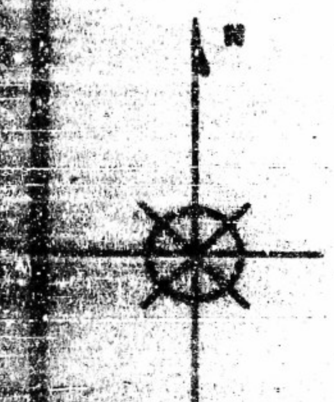
1



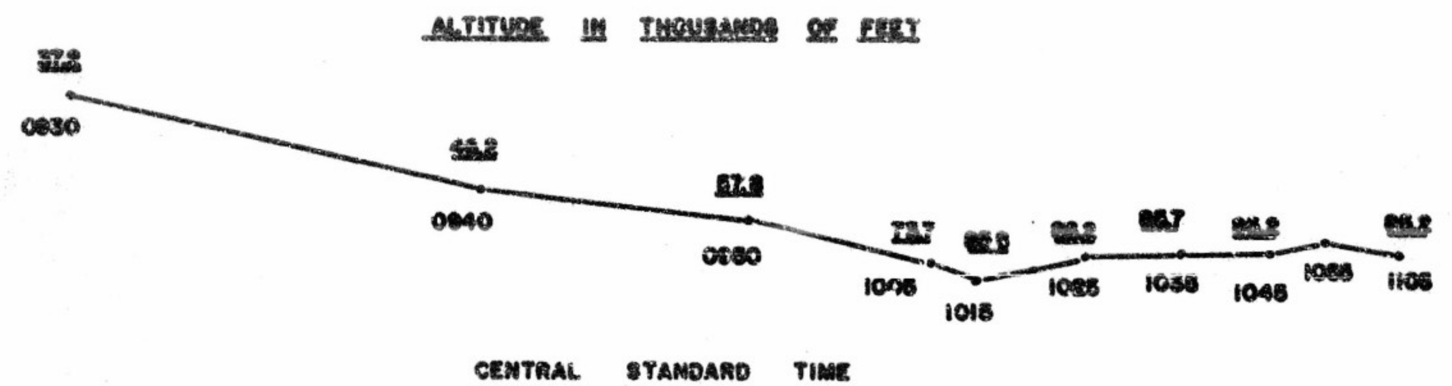
Launched at :
PYOTE , TEXAS

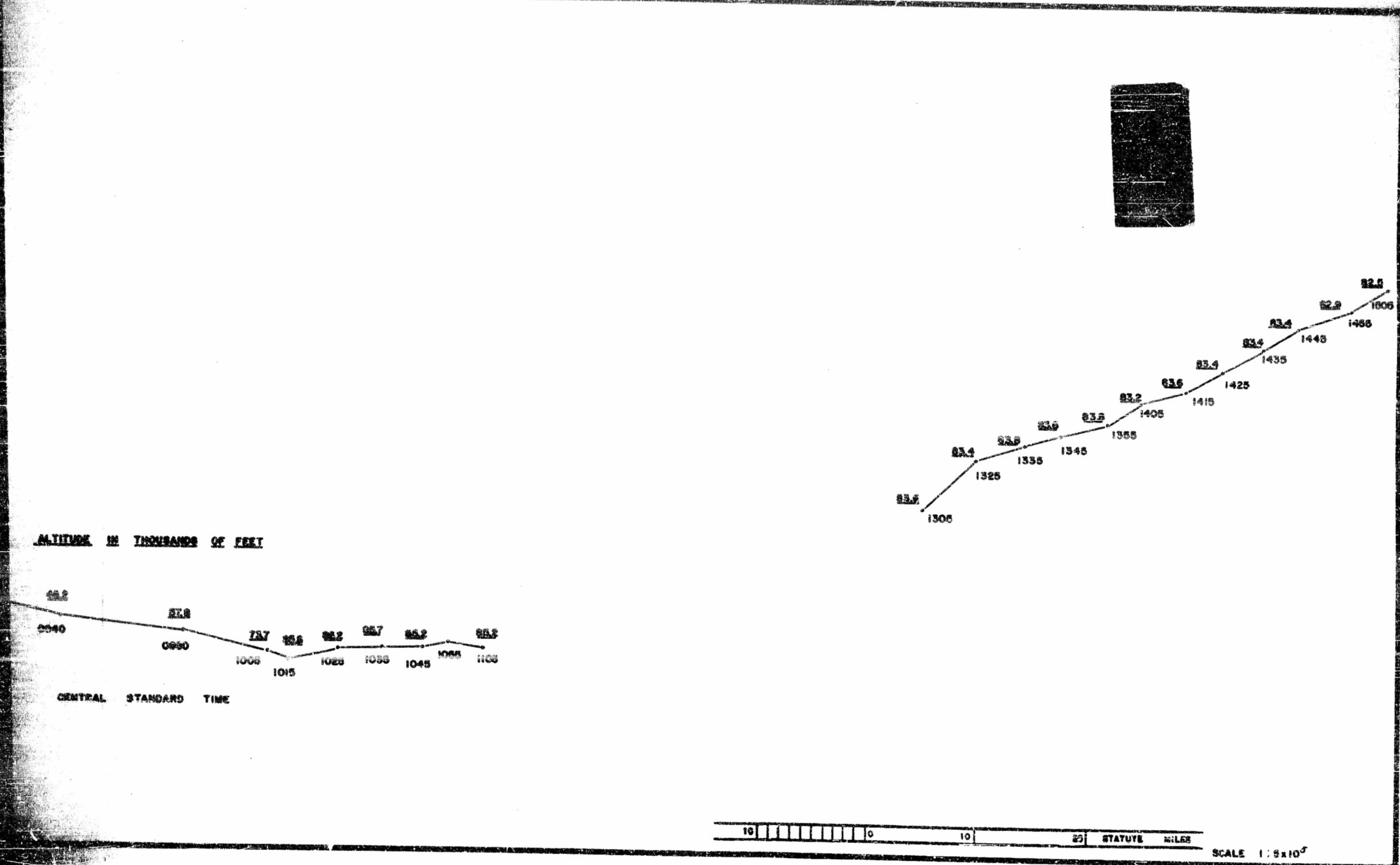
FLIGHT No. 107
Launched 0845 C.S.T.
29 January, 1953
TRAJECTORY FROM THEODOLITE FIXES

1



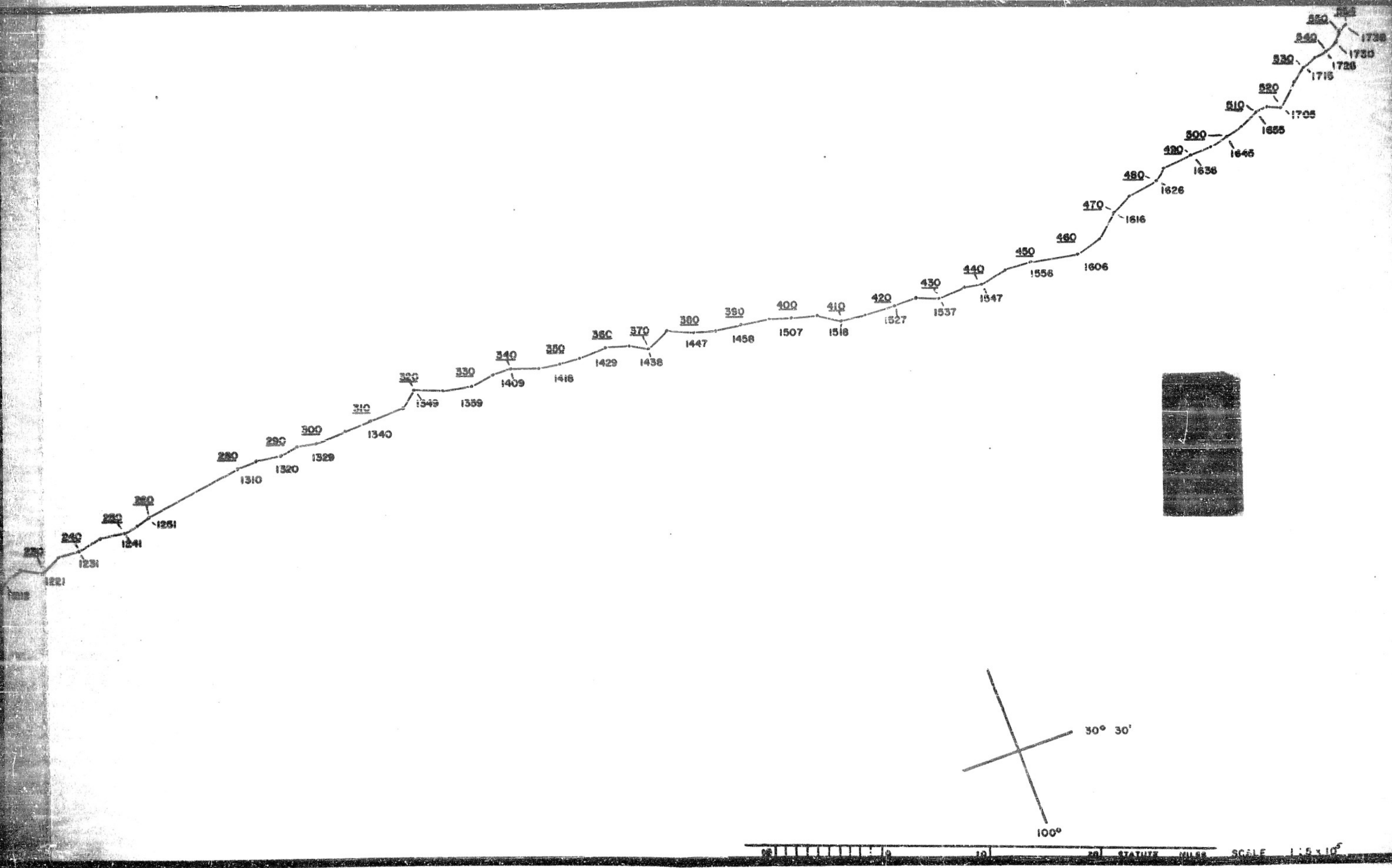
Launched at :
PYOTE, TEXAS




ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
1305
1325
1335
1345
1355
1405
1415
1425
1435
1445
1455
1505
1005
1015
1025
1035
1045
1055
1105
STATUTE MILES
SCALE 1:5x10^5

FLIGHT No.108
Launched 0845 C.S.T.
30 January, 1953
TRAJECTORY FROM DOWN PICTURES

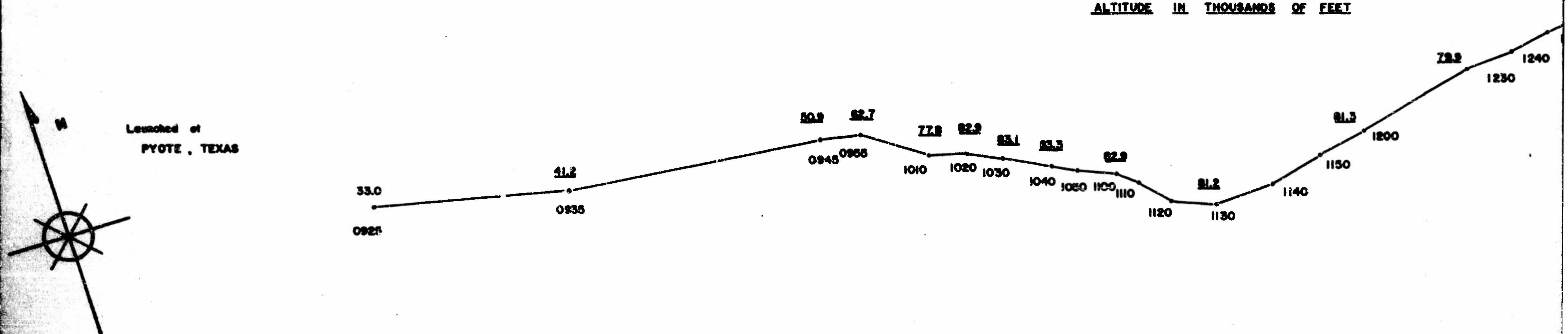
1

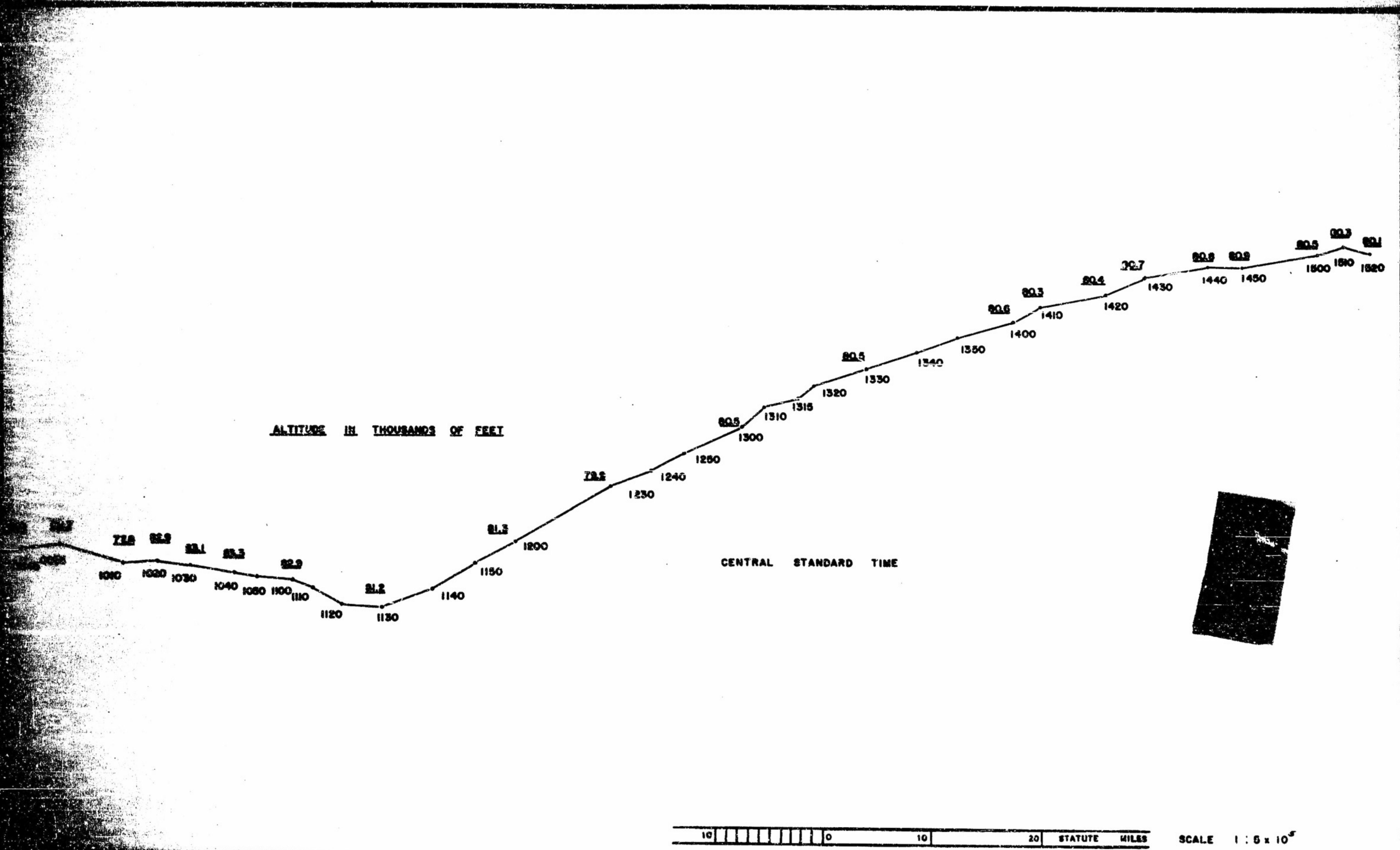

230
1221
240
1231
250
1241
260
1251
280
1310
290
1320
300
1329
310
1340
320
1349
330
1359
340
1409
350
1416
360
1429
370
1438
380
1447
390
1458
400
1507
410
1516
420
1527
430
1537
440
1547
450
1556
460
1606
470
1616
480
1626
490
1636
500
1646
510
1655
520
1705
530
1715
540
1726
1730
550
1738
30° 30'
100°
0
10
20
STATUTE MILES
SCALE

FLIGHT No. 108

Launched 0845 C.S.T.
30 January, 1953
TRAJECTORY FROM THEODOLITE DATA

1



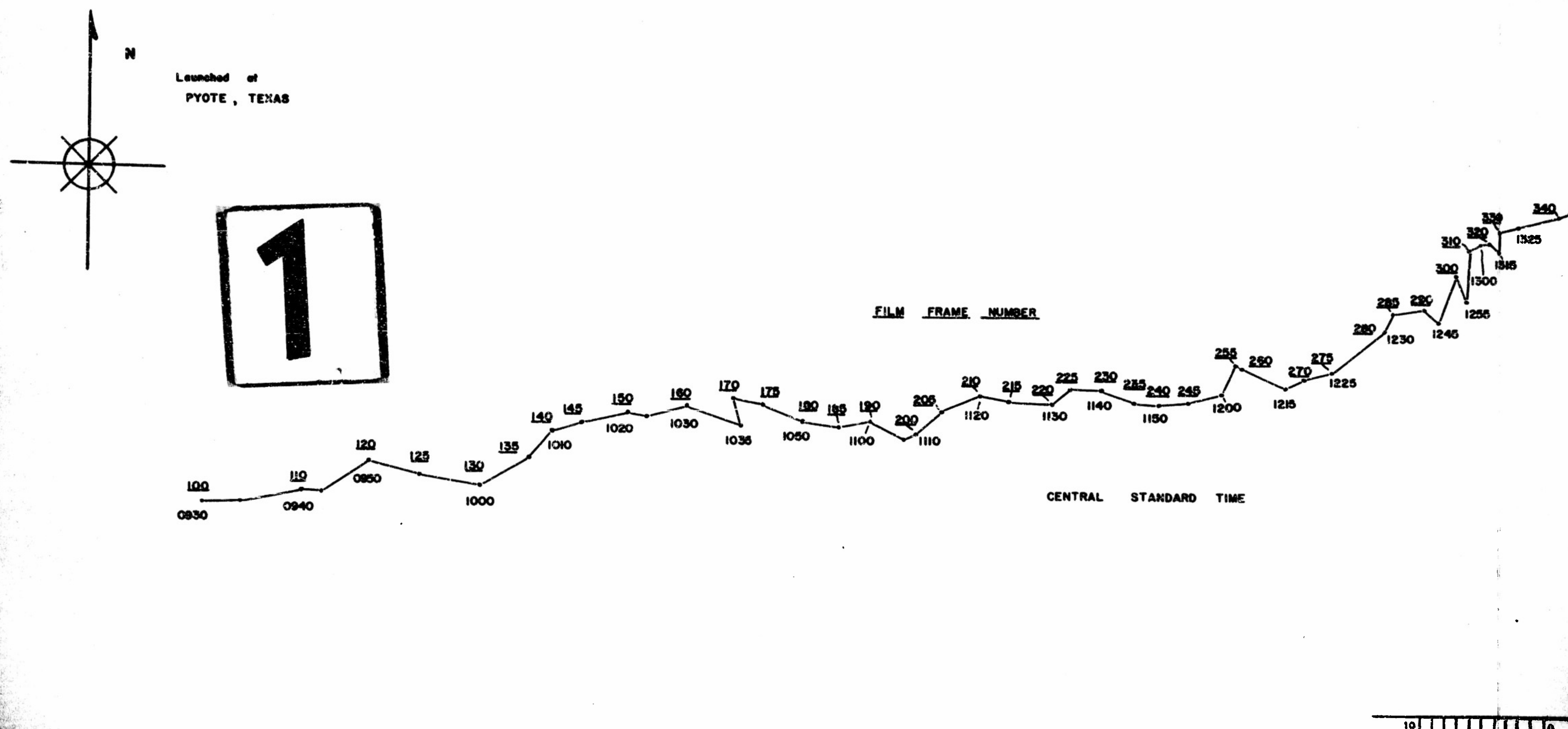

ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
1010
1020
1030
1040
1050
1100
1110
1120
1130
1140
1150
1200
1230
1240
1250
1300
1310
1315
1320
1330
1340
1350
1400
1410
1420
1430
1440
1450
1500
1510
1520
10 0 10 20 STATUTE MILES
SCALE 1 : 5 x 10⁵

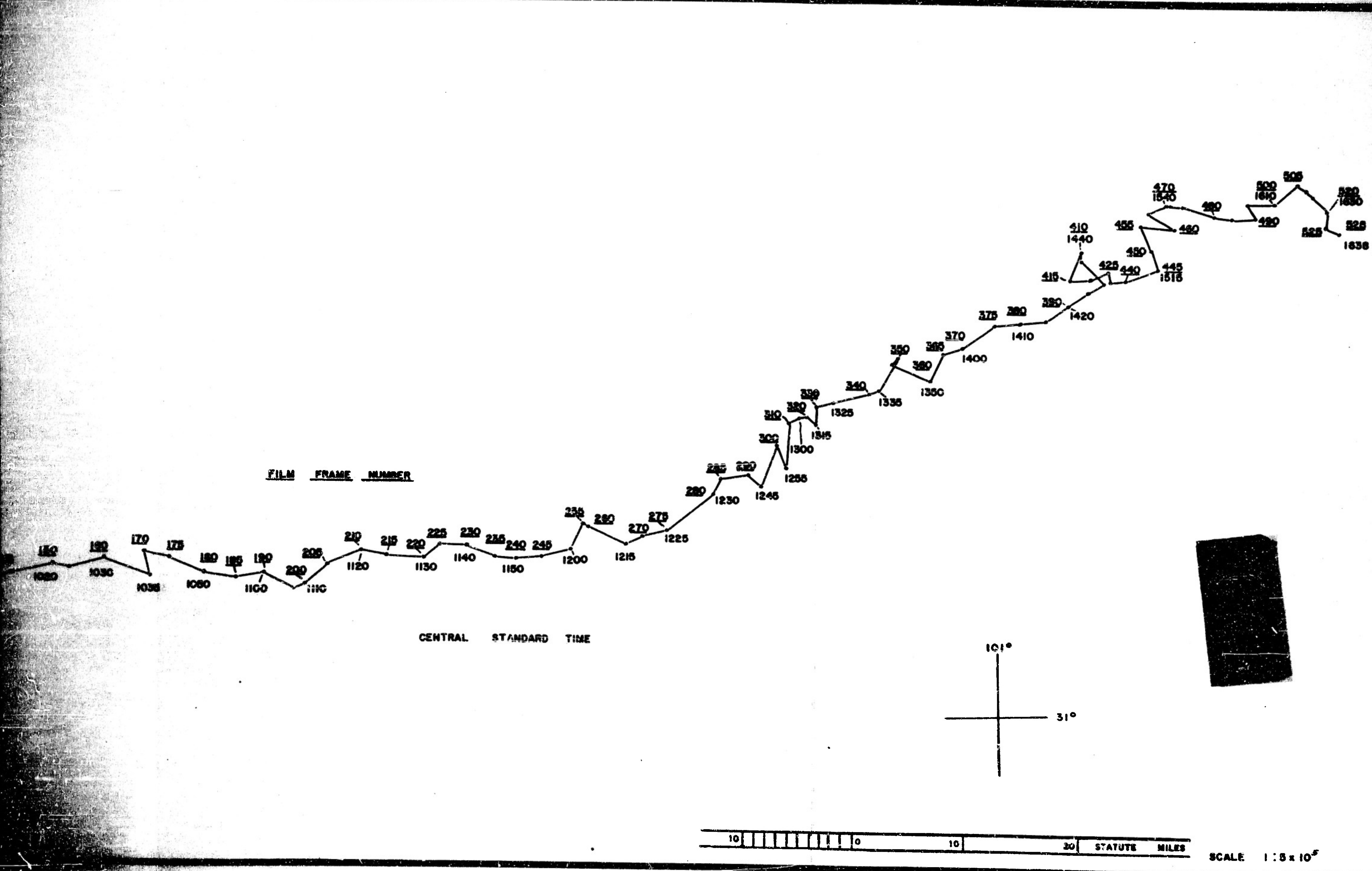
FLIGHT No. 109

Launched 0750 C.S.T.
1 February, 1953

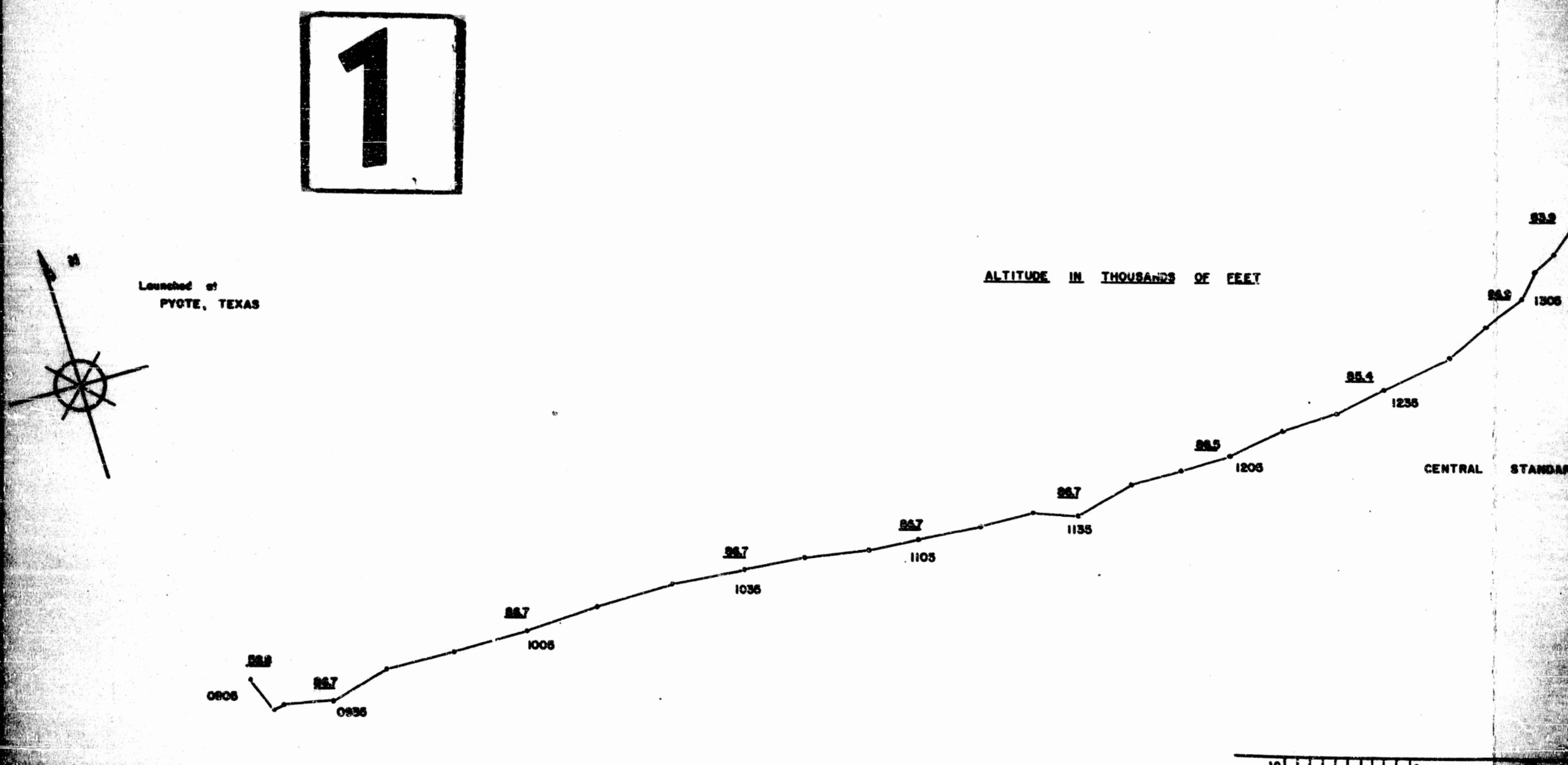
Trajectory from DOWN PICTURES

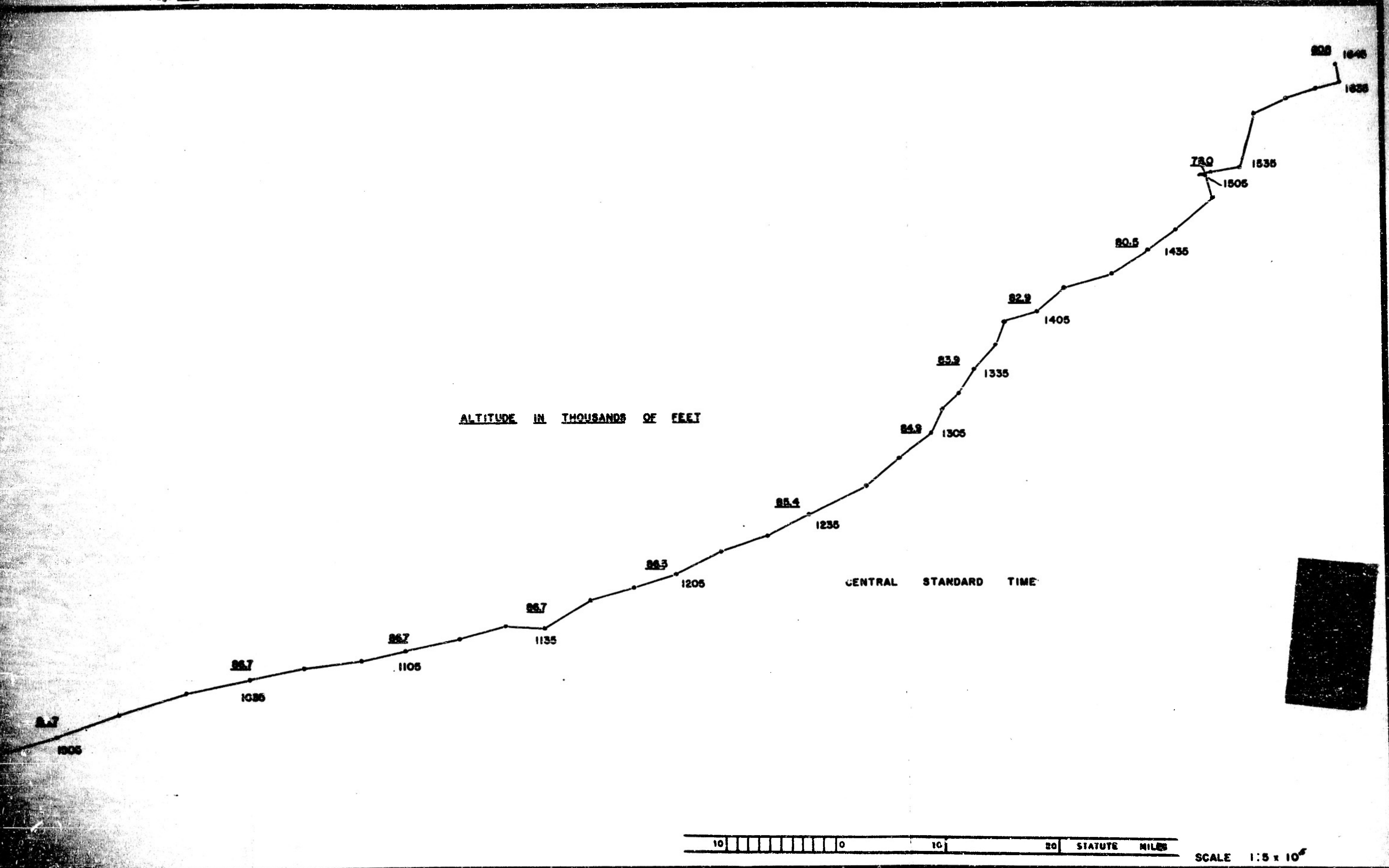
NOTE: CAMERA TILTED ~7° FROM VERTICAL



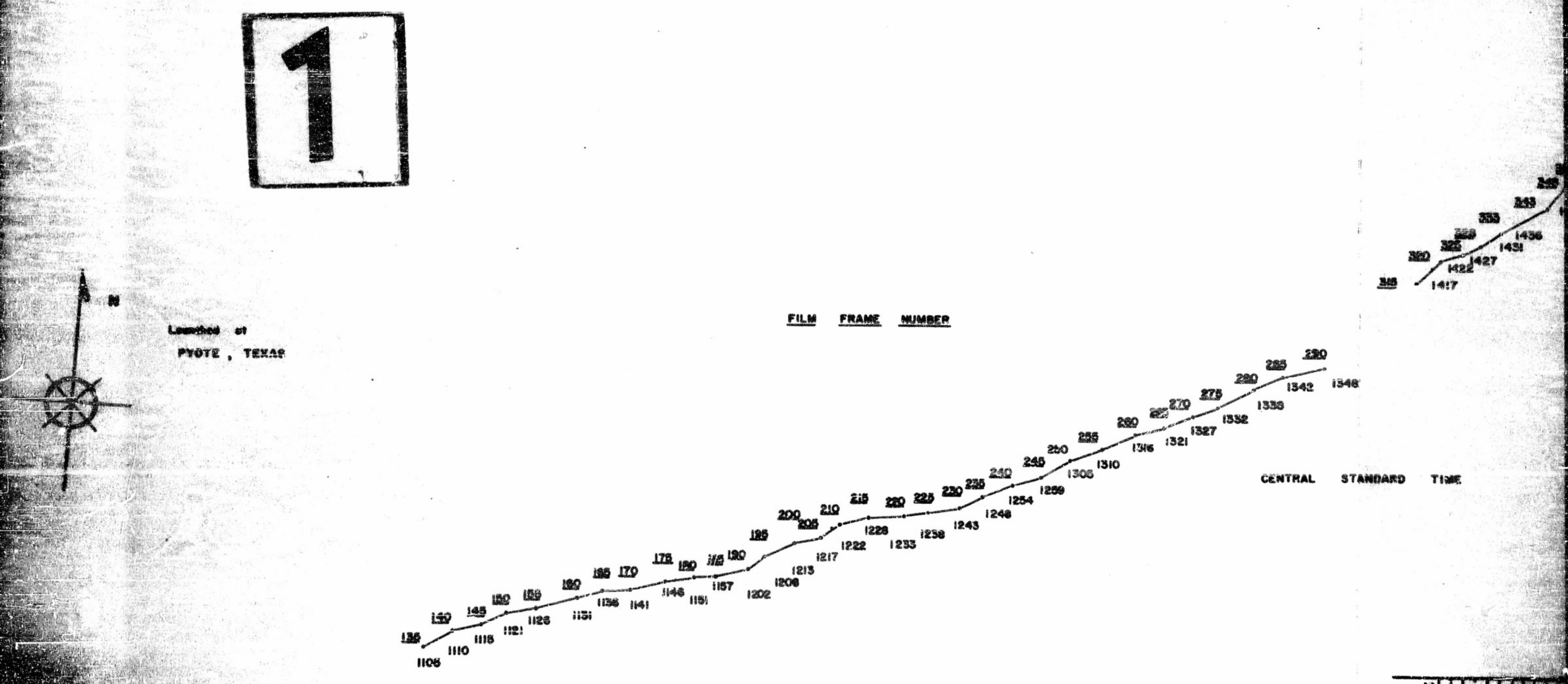

FILM FRAME NUMBER
CENTRAL STANDARD TIME
101°
31°
[redacted]
10 0 10 30 STATUTE MILES
SCALE 1 : 5 x 10^5

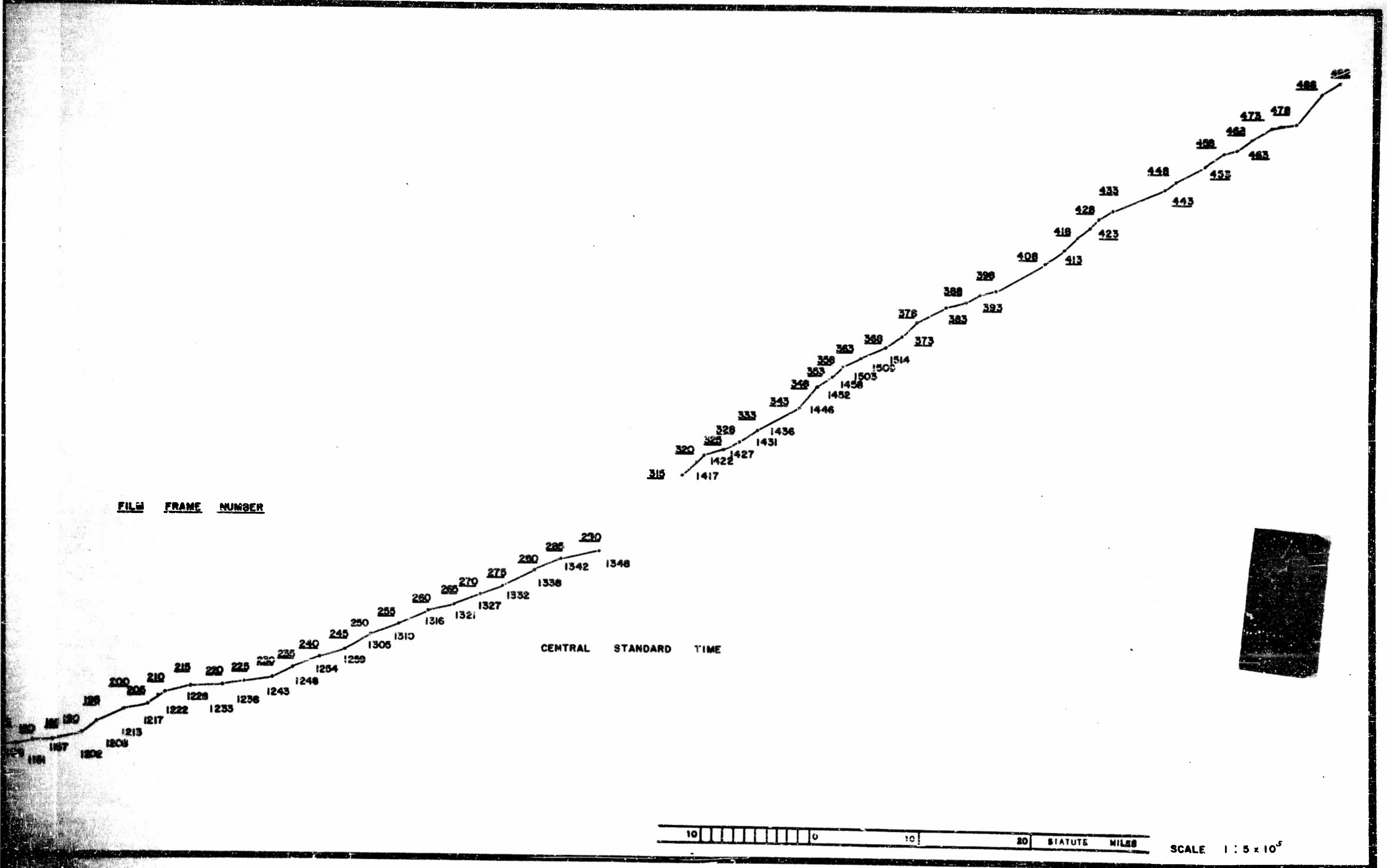
FLIGHT No. 109
Launched 0750 C.S.T.
1 February, 1953
Trajectory from THEODOLITE FIXES



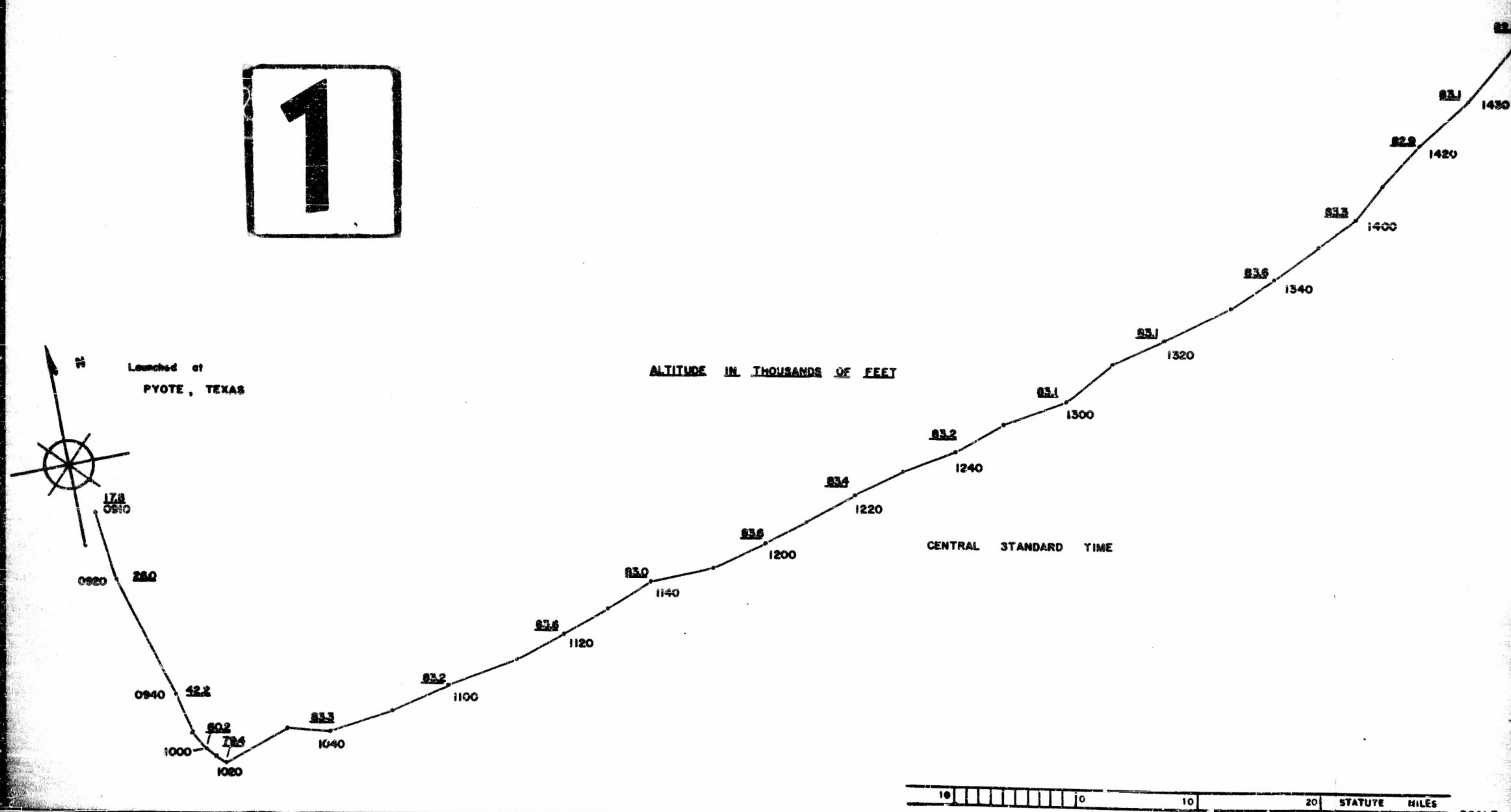

ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
1005
86.7
1035
86.7
1105
86.7
1135
86.3
1205
85.4
1235
84.9
1305
83.9
1335
82.9
1405
80.5
1435
78.0
1505
1535
1635
1645
10
0
10
20
STATUTE MILES
SCALE 1:5 x 10⁶

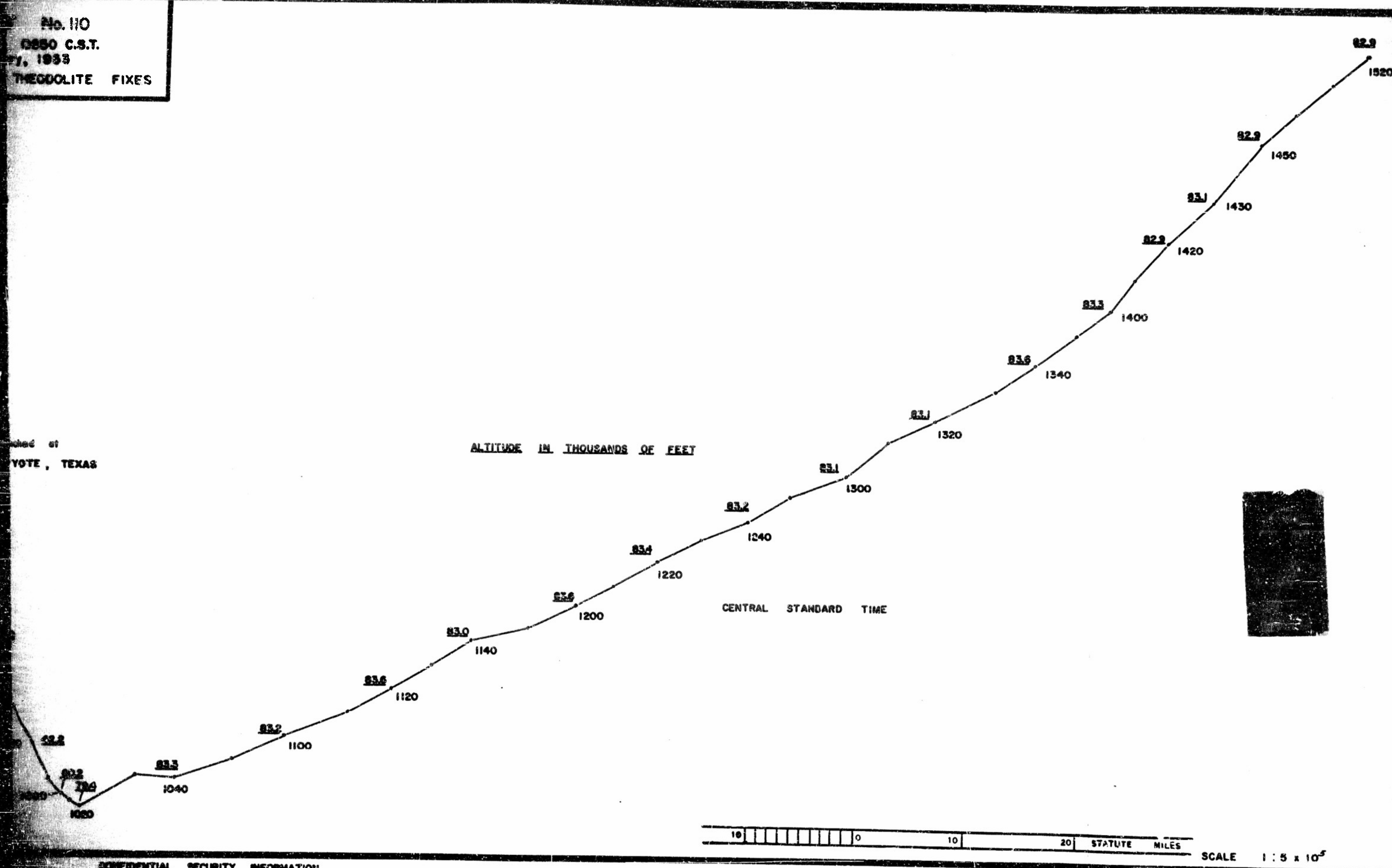
FLIGHT No. 110
Launched 0850 C.S.T.
1 February, 1953
Trajectory from DOWN PICTURES

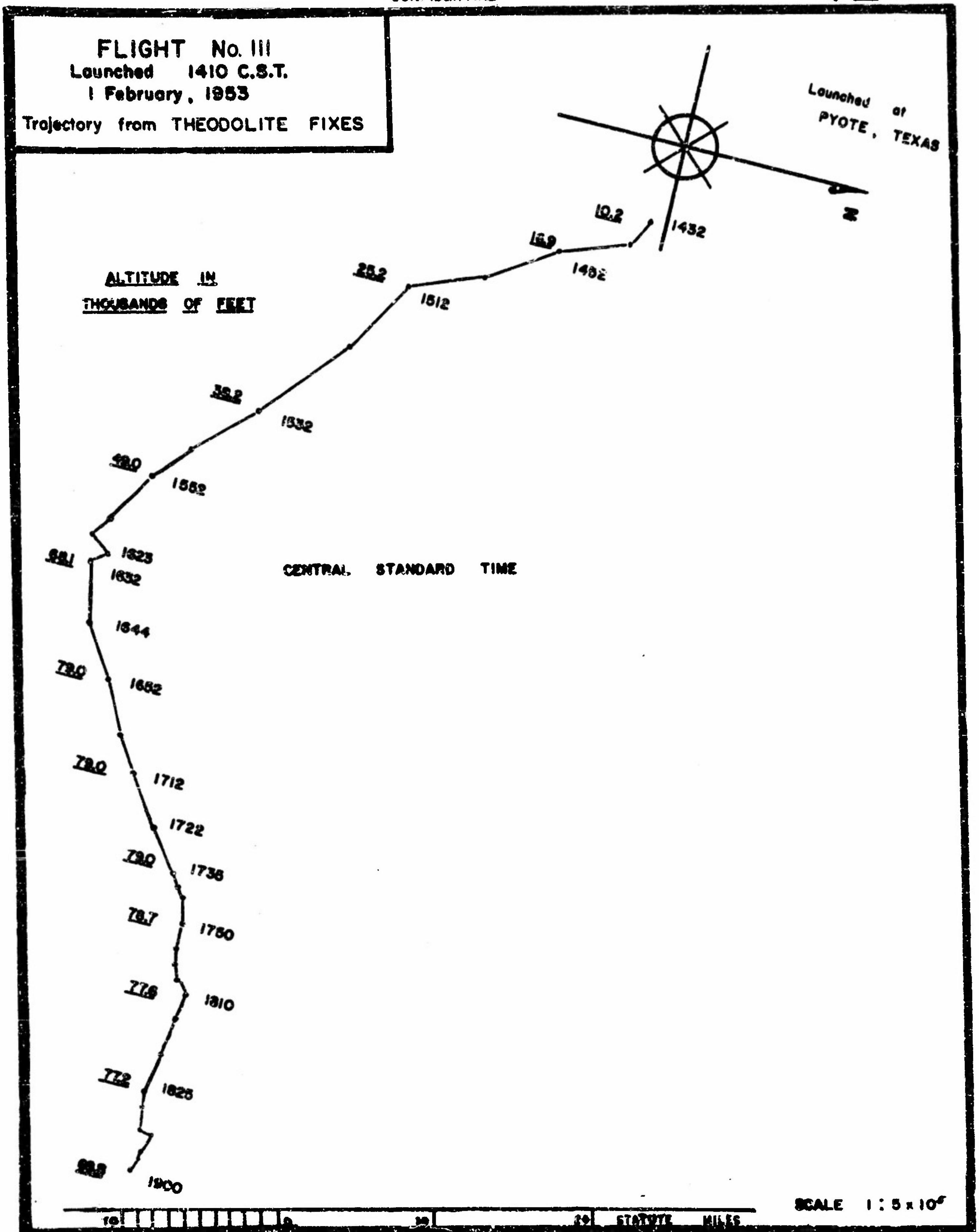



FILM FRAME NUMBER
CENTRAL STANDARD TIME
10 0 10 20 STATUTE MILES
SCALE 1 : 5 x 10^5

FLIGHT No. 110
Launched 0850 C.S.T.
1 February, 1953
Trajectory from THEODOLITE FIXES

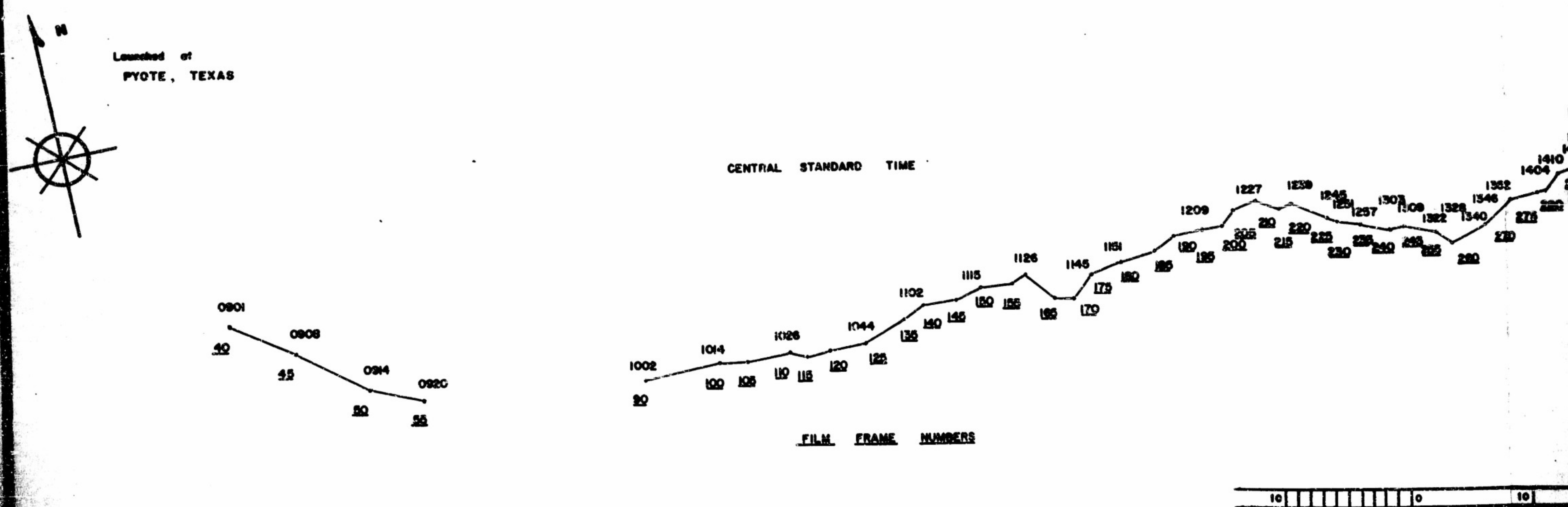


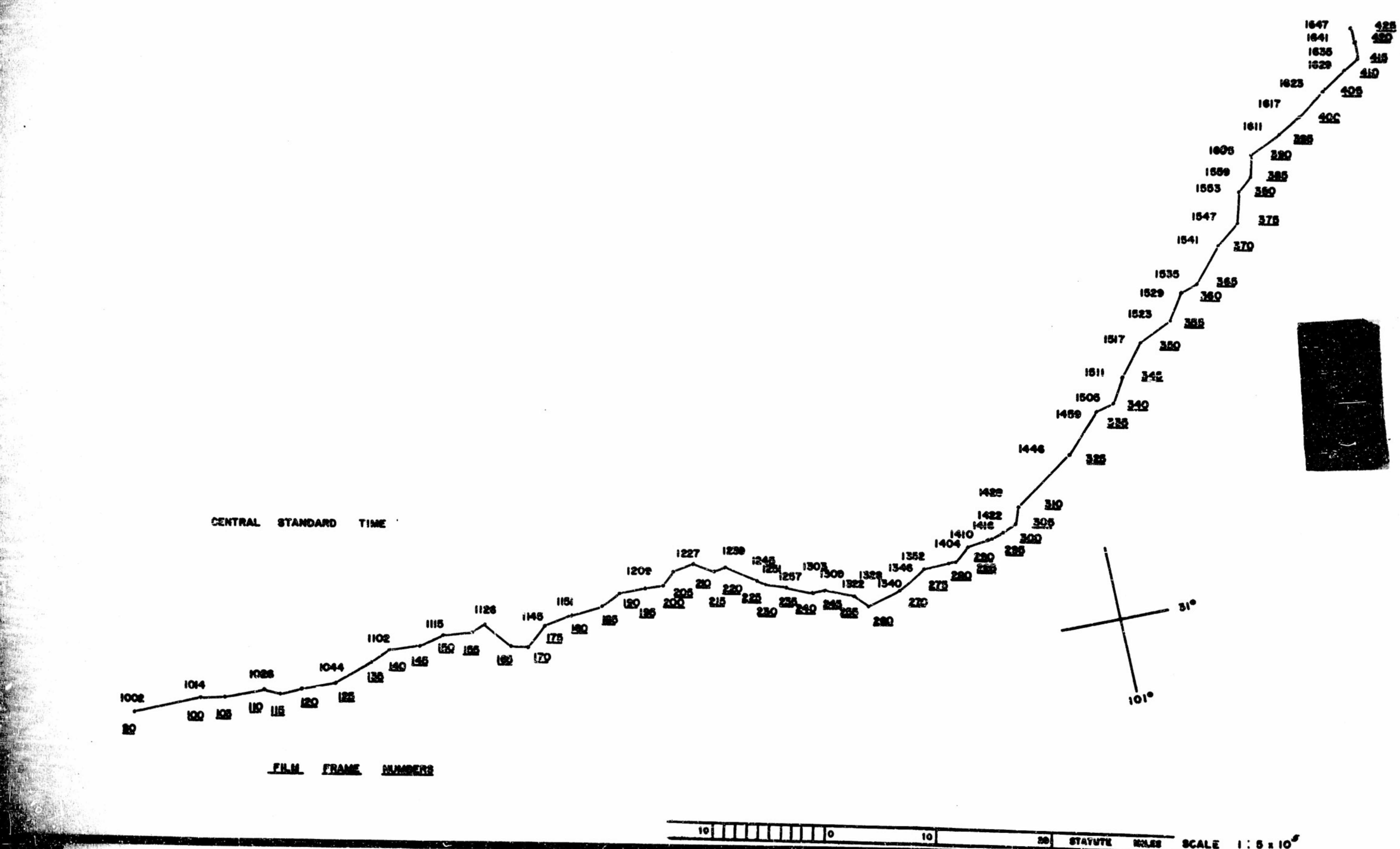

No. 110
0850 C.S.T.
y, 1953
THEODOLITE FIXES
ched at
YOTE, TEXAS
ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
82.9
1520
82.9
1450
83.1
1430
82.9
1420
83.3
1400
83.6
1340
83.1
1320
83.1
1300
83.2
1240
83.4
1220
83.6
1200
83.0
1140
83.6
1120
83.2
1100
83.3
1040
1020
[redacted]
10 0 10 20 STATUTE MILES
SCALE 1 : 5 x 10^5


FLIGHT No. III
Launched 1410 C.S.T.
1 February, 1953
Trajectory from THEODOLITE FIXES
Launched at
PYOTE, TEXAS
N
ALTITUDE IN
THOUSANDS OF FEET
CENTRAL STANDARD TIME
10.2
1432
16.9
1482
25.2
1512
38.2
1532
49.0
1552
68.1
1623
1632
1644
79.0
1652
79.0
1712
1722
79.0
1736
78.7
1750
77.6
1810
77.2
1825
1900
SCALE 1 : 5 x 10⁶
10
0
10
20
STATUTE MILES

FLIGHT No. 112
Launched 0813 C.S.T.
3 February, 1953
Trajectory from DOWN PICTURES

1

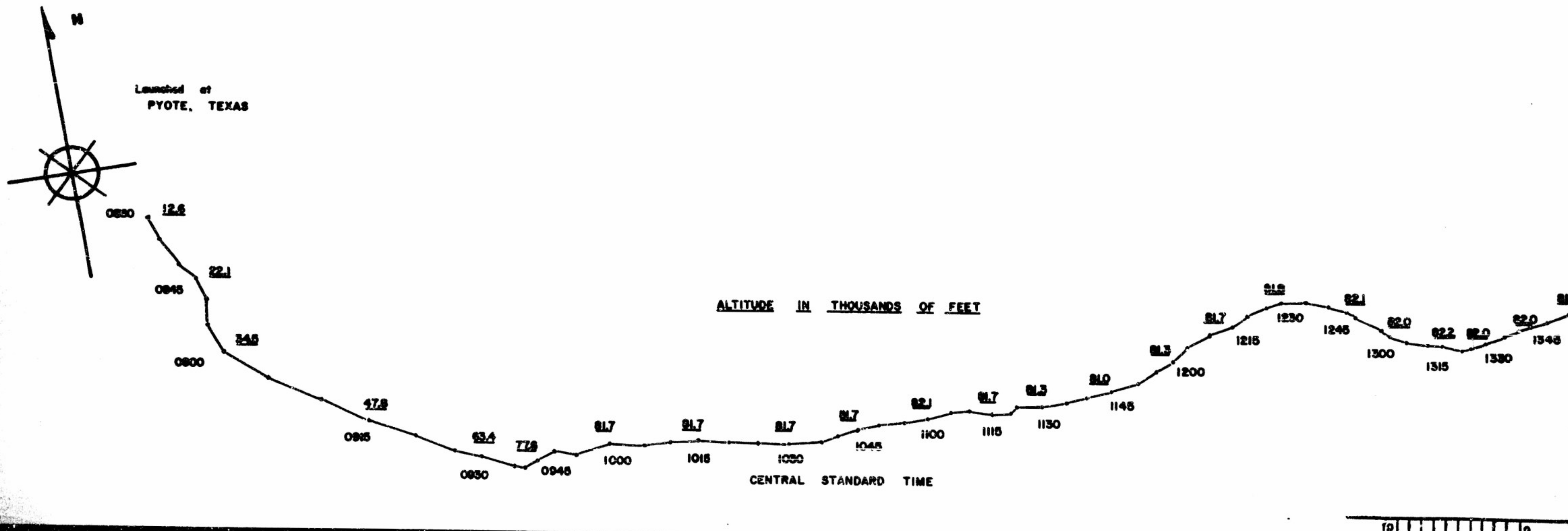


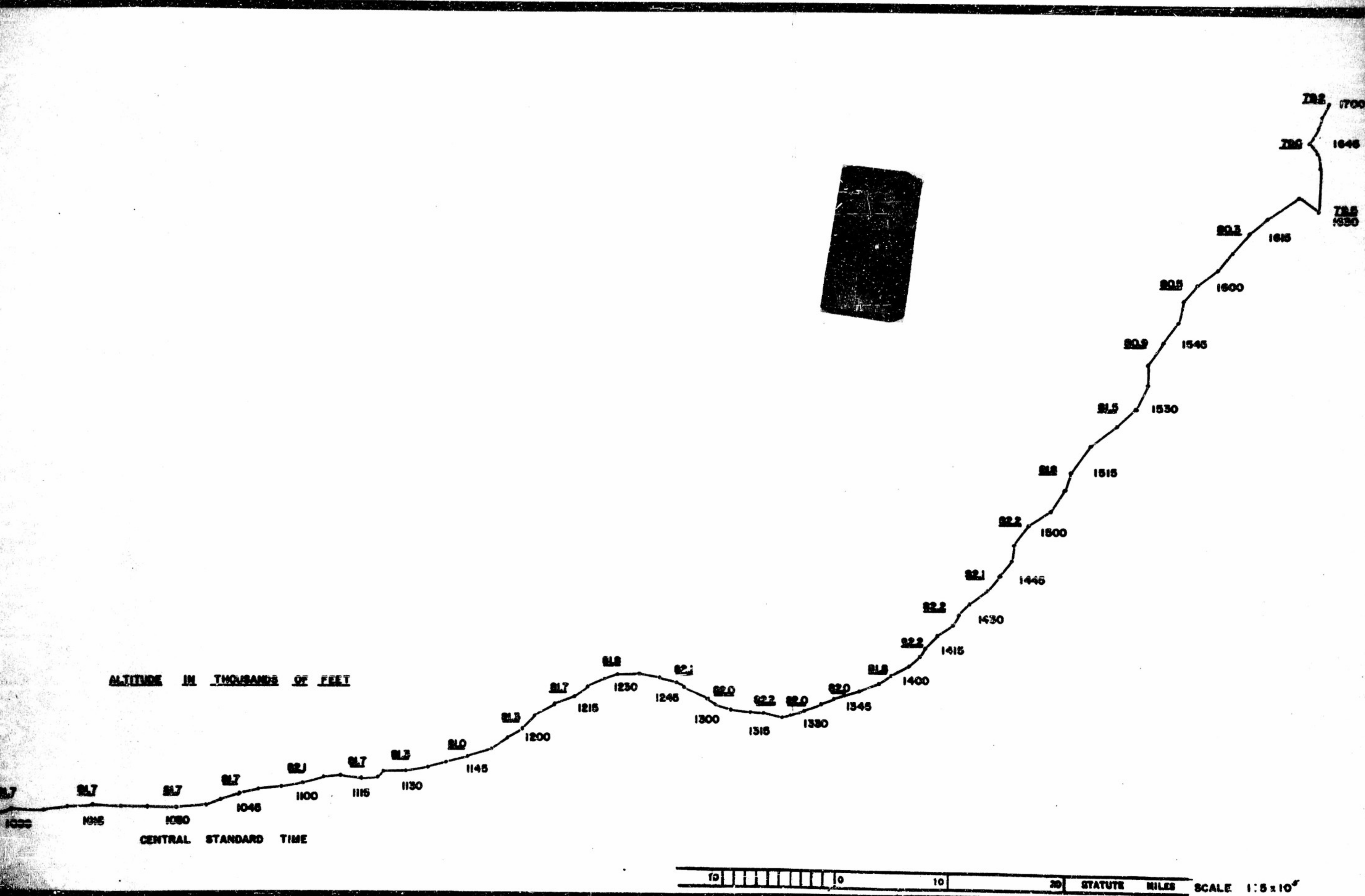

CENTRAL STANDARD TIME
FILM FRAME NUMBERS
31°
101°
10 0 10 20 STATUTE MILES
SCALE 1 : 5 x 10^5

[redacted]

FLIGHT No. 112
Launched 0813 C.S.T.
3 February, 1953
Trajectory from THEODOLITE DATA

1




ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
91.7 1000
91.7 1015
91.7 1030
91.7 1045
92.1 1100
91.7 1115
91.3 1130
91.0 1145
91.3 1200
91.7 1215
91.8 1230
92.1 1245
92.0 1300
92.2 1315
92.0 1330
92.0 1345
91.8 1400
92.2 1415
92.2 1430
92.1 1445
92.2 1500
91.8 1515
91.5 1530
90.9 1545
90.5 1600
90.3 1615
79.5 1630
79.0 1645
79.2 1700
10 0 10 20 STATUTE MILES
SCALE 1:5 x 10⁶

Section IX

METEOROLOGY

Introduction

The series of cosmic ray flights made from Pyote, Texas, during January and February, 1953, provided ten trajectories which have been analyzed to determine the characteristics of stratospheric flow. Four of these flights maintained a constant altitude for the three or more hours considered necessary for a separation of motions with different period. Information on the longer period or large-scale flow can be obtained from all ten flights; some of these flights extend over a sufficiently long period to be considered as two separate determinations of the large-scale flow. Flight 101 as the result of balloon failure, floated near sixty thousand feet for most of the day. Because this trajectory displays some rather unusual characteristics which differ from the higher level flow, this trajectory will be discussed separately.

The absolute elevations of the balloon were determined where possible from measurements on the film and also by a comparison of film and theodolite trajectories. The results of the altitude computations are given in the last portion of this section of the report.

The differences which have been observed between the camera and the theodolite trajectories are illustrated by plotting both trajectories for flight 105 on the same diagram. The systematic departure of the two trajectories is readily apparent and as discussed below, this difference may be attributed to the difference between the actual balloon altitude and the pressure altitude.

Two contradictory sun shots were made during this flight. The azimuth used in the theodolite plot was based on the final sun shot which checks the azimuth determined from the film trajectory at this point. The altitude differences tend to

obscure other trajectory differences. However, rather systematic departures in azimuth can be observed in the earlier portion of the flight and this fact along with the occasional jog in the theodolite trajectory (for example at 0940 CST) makes one suspect that theodolite errors have been introduced by the temporary mounting of the instrument.

The scale of motions

The constant level balloon trajectories of the Texas flights (lat. 32°) showed flow characteristics which are very similar to those observed at latitude 45°. Flights of eight hours duration often appear to span at least a half period of the largest scale of detectable motions. The trajectories also clearly show evidence of motion with periods of an hour or two which, as before, will be called intermediate-scale. Four theodolite trajectories were of sufficient duration at constant altitude to enable the relative "power" in the various scales of motion to be estimated. As described in the preceeding progress report,[1] the velocities, measured between observation fixes, were fitted by a linear trend for the entire interval at constant altitude. The linear function is interpreted as the description of the motion of largest scale. Motions of intermediate scale are detected by the regions of consistent departure from the linear trend; the final deviations from a linear fit are attributed to motion of smaller scale and also to error.

In Table I are listed the results of the analysis of the four Texas flights. For comparison the corresponding values derived for the stratospheric flow at northerly latitudes (45°) have been averaged for cases of easterly and westerly flow and entered in the same table. The average wind speed in these four cases was greater than that determined during either periods of east or west winds at latitude 45°. This result is corroborated by the data from all flights given in the following section. The wind fluctuations of largest scale seem significantly larger than those at 45° but in view of the higher wind speed this result does not

[1]PROGRESS REPORT ON HIGH ALTITUDE BALLOONS, Volume VII, p. II-119.

Table I

Velocity Fluctuations

			104	105	107	109	Average Pyote	Average lat 45° West winds	Average lat. 45° East winds
Flight date			1-23-53	1-24-53	1-30-53	2-1-53			
Time			12:40	11:20	11:10	10:50			
Altitude		feet	75,100	81,400	82,500	86,700	81,400	86,800	81,900
Average distance out		miles	105	110	93	60	92	68	53
Range, distance out		miles	70-140	70-150	75-110	30-90			
Leg interval		min	5	5	10	10			
Duration of flight		min	185	155	100	150	148	112	130
Mean wind magnitude		$m\ sec^{-1}$	14.1	17.7	8.8	13.2	13.5	8.1	8
Velocity direction		degrees	229	252	284	270	259	280	95
rms* velocity deviations from mean	N	$m\ sec^{-1}$	2.22	5.76	3.14	1.75	3.22	1.67	1.64
	E		3.73	4.41	2.36	2.30	3.20	1.29	1.92
rms velocity deviations from trend	N	$m\ sec^{-1}$	1.67	5.10	2.28	1.73	2.70	1.47	1.39
	E		3.73	4.25	1.82	1.61	2.85	1.09	1.50
rms long-period velocity fluctuations	N	$m\ sec^{-1}$	1.46	2.68	2.16	0.25	1.64	1.12	.81
	E		0.10	1.20	1.51	1.64	1.11	.61	.89
rms int-period velocity fluctuations	N	$m\ sec^{-1}$	0.77	1.95	1.92	.89	1.38	.58	.89
	E		0.58	——	0.92	.70	.73	——	.61
rms short period velocity fluctuations and error	N	$m\ sec^{-1}$	1.48	4.71	1.23	1.49	2.23	.84	1.00
	E		3.68	4.25	1.57	1.45	2.74	1.09	1.00
Long period acceleration	N	$X10^{-2}cm\ sec^{-2}$	-4.56	10.48	12.53	-.94	7.13	6.1	5.0
	E		-.19	4.42	8.76	-6.32	4.90	3.2	
Average intermediate period acceleration	N	$X10^{-2}cm\ sec^{-2}$	8.55	20.22	20.50	6.73	14.00		
	E		18.06	——	21.80	8.31	12.04	——	11.0
Average length of the intermediate periods	N	min	130	120	100	150	125	——	——
	E	min	80	——	80	140	100		

* rms = root mean square

necessarily indicate a higher relative variability of the wind. The wind fluctuations of intermediate scale as before are quite large compared to the total wind variation. The values for the fluctuations of smallest period includes the error in position fix. Since there is reason to suspect the accuracy of positioning in this case, it is difficult to attach much significance to the magnitude of the small scale fluctuations.

Summary of the large-scale flow

A summary of the large-scale stratospheric flow was also made following more conventional methods of climatological analysis. From a consideration of the trajectory errors and the effect of small scale motion, it was decided to require a fifty-minute period with a constant altitude maintained within a thousand feet for the determination of the wind velocity. In an attempt to increase the amount of data the velocity was determined at the beginning and at the end of the longer trajectories, since these wind observations would be hours apart corresponding to the conventional interval between upper air reports.

The results of these wind measurements are given in Table II. The mean wind vector for these seventeen cases is from 250° at 21.6 knots (11.2 m sec^{-1}). Some further significance of the observation of a mean southerly component of the wind is gained by noting that the six General Mills trajectories of winter SKYHOOK flights made in the Southwest all showed a southerly component of the flow in the layer 80,000 to 90,000 feet.

The relative variability of these observations may be described[1] by the constancy q, defined by the ratio of the mean vector wind speed to the mean wind speed $V_r/V_s \times 100$. The constancy for these cases was found to be 95%

[1]Brooks, C.E.P., C.S. Durst, N. Carruthers, D. Dewar and J.S. Sawyer, "Upper Winds Over the World", Meteorological Office, Geophysical Memoir No. 88.

Table II

Measurements of Large-Scale Winds in Knots

Flight	Date	Time CST	Press Alt Thsd ft	East-west	North-south	Wind speed
101	20 Jan	1000	89	26.8	3.8	27.0
103	21 Jan	1030 1500	81 80	13.9 20.7	15.4 16.8	20.8 26.6
104	23 Jan	1000 1330	79 75	15.6 19.7	14.7 15.6	21.5 25.1
105	24 Jan	1000 1230	83 84	27.6 33.0	8.3 18.2	28.8 37.7
107	30 Jan	1120 1445	86 83	15.9 19.9	0 8.2	15.9 21.3
108	30 Jan	1030 1430	83 80	11.6 23.4	-6.4 -2.6	13.2 23.5
109	1 Feb	1100	(81)?	23.1	2.4	23.2
110	1 Feb	1130 1500	83 83	23.1 14.4	7.9 13.2	24.5 19.8
111	1 Feb	1715	79	14.2	8.2	16.4
112	3 Feb	1030 1500	82 79	21.8 15.9	0 13.4	21.8 20.8
Mean				20.03	8.06	22.8

very nearly the same as for the Minneapolis cases of east winds which was 96%. Tropospheric values of q are generally much lower, usually less than 90%.

The data was examined for any systematic variation with altitude in the layer 80,000 to 90,000 feet but none was detected. Only in the region 65,000 to 80,000 feet could a definite increase in wind speed with elevation be established.

The one systematic variation of the wind which was observed, appeared in the comparison between morning and afternoon winds. The early afternoon flights showed a tendency to have a greater southerly component than the morning observations. The vector mean winds for the nine morning and eight afternoon observations are compared in Figure 1. If as assumed by Brooks, loc. cit., the wind record can be adequately represented by a vector normally distributed about the mean vector, the standard vector deviation may be derived from the constancy q and the mean wind.

The values of S_v, the standard vector deviation for the morning and afternoon observations, are also given in Figure 1. One can interpret differences between morning and afternoon winds as a possible indication of diurnal effect or merely a standing wave in the flow pattern.

Flight 101, possible anticyclonic flow about a low

The anticyclonic trajectory of flight 101 was observed in the lower stratosphere (about 60 thousand feet) and since small complex flow patterns had previously been indicated in this region the rather unusual feature of this trajectory was not immediately apparent. As may be seen from the sketch on the diagram of the theodolite trajectory, this trajectory very nearly describes a semicircle of 18 miles radius from 1130 CST to 1500 CST. The speed along this path was surprisingly constant at 7 m sec^{-1}. The centripetal acceleration of 15 x 10^{-2} cm sec^{-2} is more than twice the magnitude of the Coriolis acceleration of 6 x 10^{-2} cm sec^{-2} and is, of course, oppositely directed. A steady flow of this

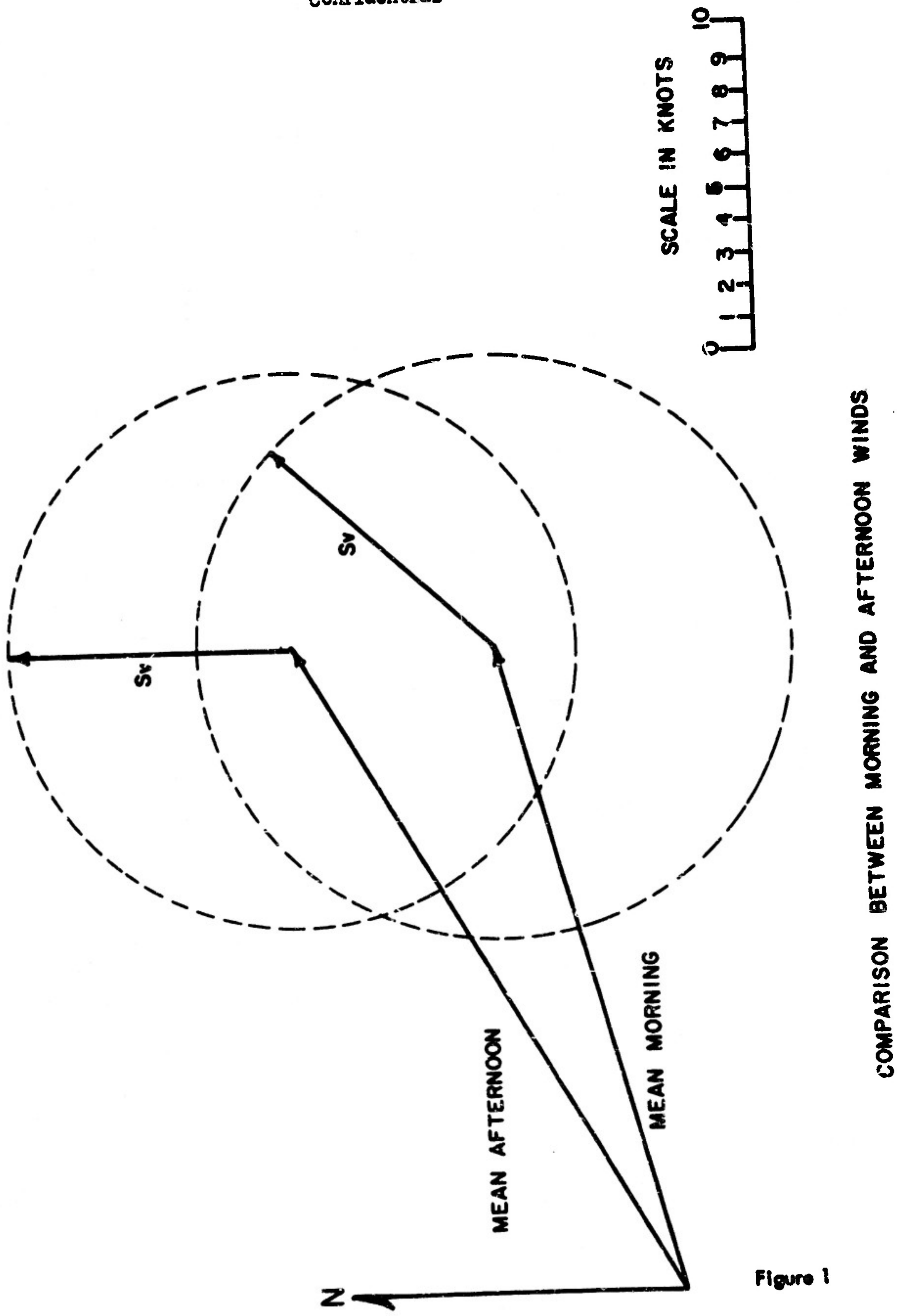

SCALE IN KNOTS
0 1 2 3 4 5 6 7 8 9 10
Sv
Sv
MEAN AFTERNOON
MEAN MORNING
N
COMPARISON BETWEEN MORNING AND AFTERNOON WINDS

Figure 1

type could only correspond to flow about a low pressure center. As suggested by Forsythe[1] this result is equivalent to specifying that the geostrophic wind field (or field of pressure gradient force) is linear.

The possibility that the apparent centripetal acceleration is actually an observation of vertical wind shear cannot be entirely discounted since the altitude of the balloon does not remain entirely constant. The total vertical change in balloon elevation is less than four thousand feet, however, and the wind shear would have the magnitude of 12 m sec^{-1} (or 23 kts) in four thousand feet, certainly a large value of the shear in regions of low wind speed.

Conclusions

1. Large-Scale Flow. The analysis of the trajectory data indicates that the observed large scale flow can be adequately represented by a steady westerly current (from 250°) at about 20 knots. Superimposed on this basic current are velocity oscillations with a somewhat smaller period and smaller amplitude than large-scale tropospheric flow. The amplitude of the corresponding horizontal oscillation is almost an order of magnitude smaller than for tropospheric motion. Unless larger velocity fluctuations with long periods occur (which can only be verified by a longer period of observation) the relative variability of these large scale winds is less than in the troposphere and is approximately the same as that determined for the stratospheric easterly winds.

The flow at sixty thousand feet again seems to differ from the higher level flow. The type of trajectory shown by flight 101 suggests that the pressure patterns in this region are small and change erratically.

2. Intermediate Scale of Motions. It is difficult to compare the magnitude and effects of intermediate scale motions with either stratospheric easterly flow or flow in the troposphere because of the limited data available. The effects of

[1]Forsythe, G.E., 1949 "Exact Particle Trajectories for Non-Viscous Flow in a Plane with Constant Coriolis Parameter". J. Met., 6 p.3

intermediate scale velocity fluctuations will be appreciable for those cases with amplitude of about 2 m sec^{-1}. Since the total wind speed is low and the velocity fluctuations in the largest period of oscillations are not much larger than those with intermediate period, the separation of large and intermediate scale of motions in the stratosphere will be difficult. It is unlikely, for example, that it would ever be possible to chart these large scale stratospheric motions on a synoptic map because of high value of the "noise" produced by intermediate fluctuations (as well as the fact that the large-scale motion is relatively small compared to the spacing between meteorological observations).

3. Small-Scale Motions. The motions called small-scale would be fluctuations with periods of about 20 minutes. In the troposphere such motions would undoubtedly be attributed to thermal convection. While some correspondence between the small fluctuations in the theodolite and the film trajectories does verify the existence of such motions, the accuracy of the position fixes does not permit a determination of their magnitude.

DETERMINATION OF BALLOON ALTITUDE

The absolute altitude was computed for a number of the Texas flights, the altitude was computed in two ways:

(1) From measurements on the down camera photographs; and

(2) From the horizontal distance out to the film fix and the elevation angle read by the theodolite.

This latter method is only possible where accurate timing of the film was available from the telemetered record on the film.

The accuracy of both methods leaves much to be desired. The quality of the film was not uniformly good, possibly due to atmospheric haze. The cameras were not always suspended perpendicularly, which introduces an error in both methods. The altitude computation from film measurements depends directly on the accuracy

of the base map, which for the Texas area was not entirely satisfactory. Only a limited number of computations could be made by this method.

The accuracy of the second method was obviously decreased by the temporary mounting of the theodolite; the elevation angle could be seen to vary during the day from successive sun shots. Another error in this method is introduced by the fact that the exact theodolite location is known only to within about a half-mile. This could cause an elevation error of about 1000 feet in values taken early in the flight but only 500 feet error in some of the computations at greater distances out.

The results of the computation may be seen in Table III where computed absolute elevations are compared with pressure altitude.

The absolute altitude in all but one case (where it was equal) was lower than the indicated pressure altitude. A certain portion of this difference may be accounted for by the stratospheric temperatures which were lower than that assumed for the standard atmosphere. In all cases the mean temperature in the layer 100 to 50 mb was below -65° C. If this same temperature departure is maintained in the layer up to 30 mb, the elevation of the 30 mb surface would deviate in elevation from the standard atmosphere by:

$$25.3 \times 10/218 = 1.2 \text{ thousand feet}$$

(Since the height difference is 25.3 thousand feet.)

The difference between the pressure altitude and absolute elevation in flights 103, 104 and 107 is no greater than the error in absolute measurement plus the deviation from the standard atmosphere. Hence no error in pressure is detectable for these flights. The difference in the case of 110 is sufficiently large to suggest an error in pressure of about 1 mb. (The pressure reading is too low.) Flight 109 seems to be seriously in error although camera tilt and lack of telemetered data hinder a more complete check.

Table III

Computed Elevations for Some Texas Flights in Thousands of Feet

Flight Date	Frame No.	Time CST	Elev MSL Film Measurements	Elev MSL Film Fix	Press. Alt. MSL	
103	122	10:30		79.1	81.3	
	210	12:00		78.6	80.9	
	313	13:45		78.6	79.4	
	453	16:10		77.6	79.4	
104	80	9:25		76.1	80.9	
	143	10:26	74.0		76.7	
	147	10:30		73.6	76.7	
	187	11:12	73.3		75.4	
	195	11:20		71.9	75.4	
	253	12:20		73.8	74.8	
	310	13:20		73.6	75.1	
	363	14:15		72.9	74.8	
					(Project Gond.)	(Cosmic Ray. Gond.)
105	128	9:50		79.6	82.1	83.5
	187	11:05		80.6	81.3	83.4
	242	12:00		80.6	81.3	83.8
	300	13:00		81.3	81.3	83.8
	323	13:23	78.4		80.9	83.2
107	108	10:35		82.6	85.7	
	182	11:47	82.9*		85.0	
	254	13:05		82.0	83.6	
	331	14:25		82.2	83.4	
109	200		79.3**		86.7	
110	133	11:03	80.7		83.2	
	140	11:10		76.6	83.2	
	208	12:20		79.8	83.4	
	227	12:40		81.2	83.2	
	235	12:48	78.9		83.3	
	259	13:10		80.8	83.2	
	280	13:30	80.3		83.8	
	326	14:20		80.2	82.9	
	374	15:10		79.8	82.9	
112	425	16:46		77.3	79.0	

* No calibration film, used same as 105

** Bad camera tilt

Since the stratospheric flow was quite similar in all these flights, it almost precludes the possibility of any great temperature fluctuations in a deep layer and therefore the departure from the standard atmosphere should remain almost constant during these flights. The close correspondence of the pressure altitude and absolute elevation in flight 105 therefore suggests that the pressure reading of the telemetered data was too high. On this flight a pressure reading was also made in the cosmic ray gondola and these values of pressure were lower and are therefore assumed to be correct.

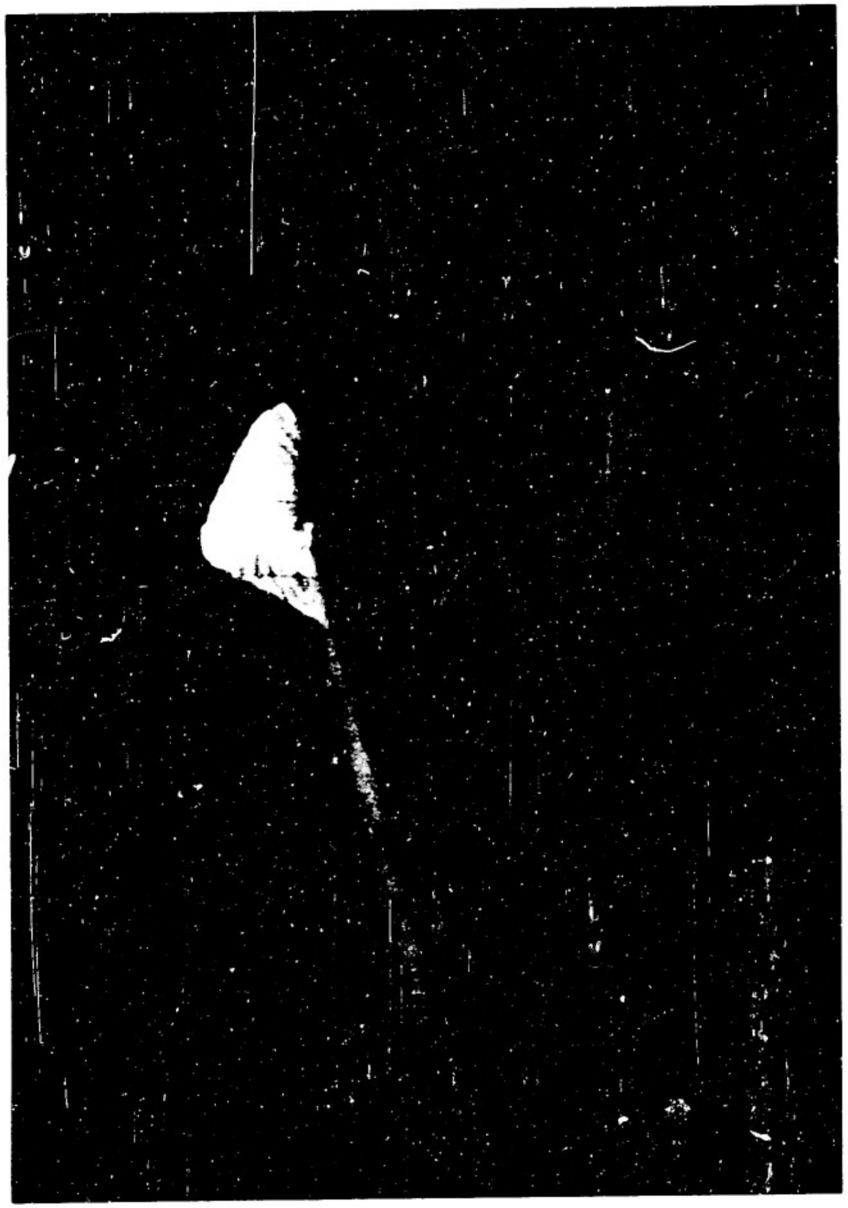
Flight 112 absolute elevation was computed using the position just before blow-down. Camera tilt and lack of calibration prevented film measurement and the lack of timing on the film exclude other position checks.

Section X

THE USE OF DRY ICE AS A BALLASTING AGENT

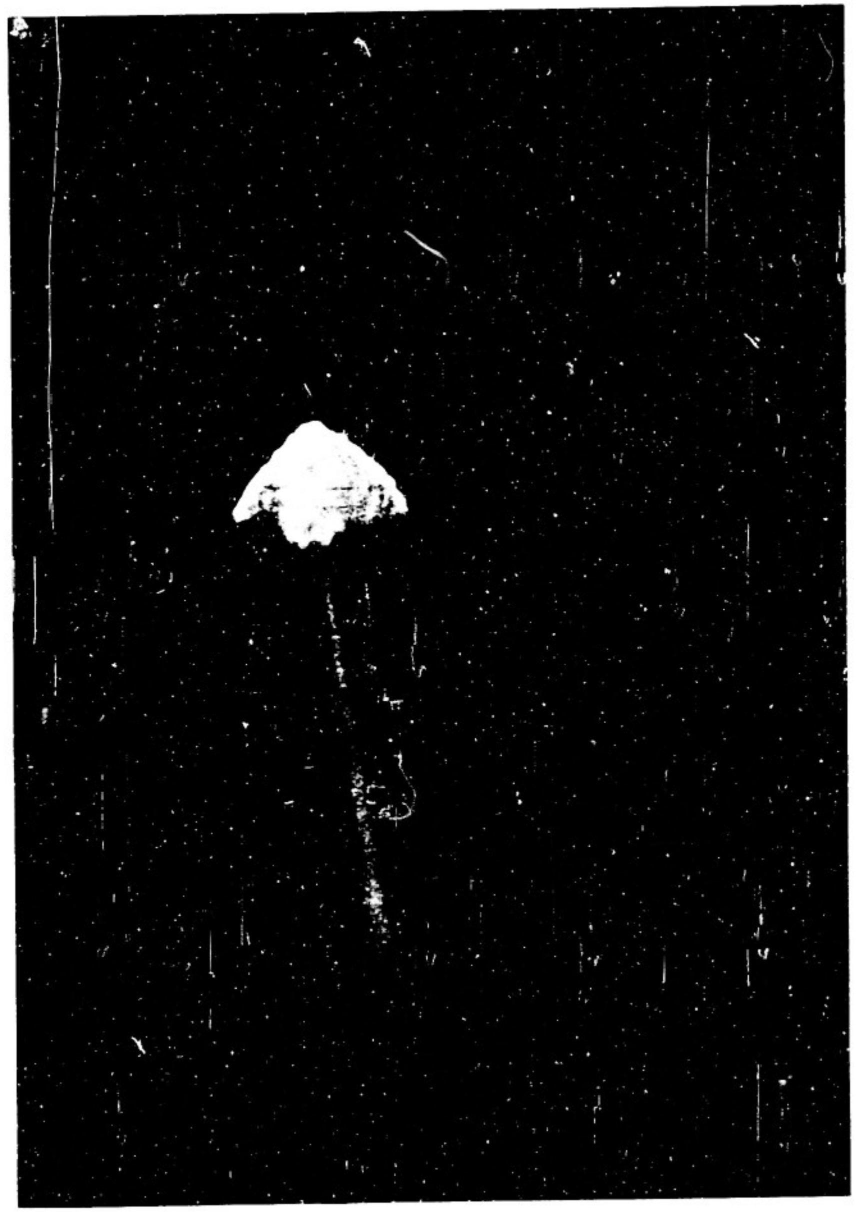
In anticipation of the fact that balloons equipped with duct type appendices would be more unstable at ceiling altitude than balloons with open bottom appendices which could take air freely on descent, some sort of ballasting seemed to be necessary. The decision was made to include on each flight a block of dry ice hung in a net bag below the gondola. The dry ice would be photographed by the down camera and the rate of evaporation could be determined. It was anticipated from previous experience that the rate would be sufficient to compensate small decreases in lift due to leakage or other sources of unbalance. This section of the report summarizes the results of the dry ice measurements during the Texas series of flights. A typical down picture showing the appearance of the dry ice hanging in the net bag is shown in Figure X-1. This photograph was taken during flight 103 from an alttitude of 82,000 feet at a geographical position of 32° north latitude and 101° west longitude. The evaporation of the dry ice can be easily seen in Figure X-2 where Figure X-2a was taken shortly before the balloon reached ceiling and Figure X-2b was taken the following morning after sunrise. The amount of dry ice remaining was determined by projecting the down pictures and tracing the apparent outline of the block. The area of this tracing was determined and it was assumed that the surface area of the block was proportional to this projected area as seen in the photographs. The mass of ice was then assumed proportional to the projected area taken to the 3/2 power. The initial weight of the block was known and a projected area was measured very close to the beginning of the flight, at which point the measurements and the actual value were normalized. Then the mass of dry ice remaining could be plotted as a function of the time of flight. These plots are given in Figure X-3a and b for all of the flights in which dry ice were included. They are very closely the same in that there is a very rapid initial loss of weight while the balloon is

Figure X-1. A typical down picture obtained on the Texas series, flight 103, altitude 82,000 feet, 1322 CST. The white object in the foreground is the dry ice chunk hanging in a fishnet bag. Just to the right of this is the town of Sparenberg, Texas. The one mile square section lines can be used for determining the balloon altitude by referring to a calibration photograph taken before the flight. From such photographs very exact trajectories as well as balloon altitudes may be obtained. (See section IX for results of such measurements).



1820 CST - 20 January

a



0750 CST - 21 January

b

FigFigure X-2. Comparison of the dry ice at the beginning and end of flight 102 at the times indicated under each Fropicture. From such photographs the rate of evaporation of the ice was determined by assuming that the projected thearea seen in these photographs was proportionate to the surface area of the cake of ice.

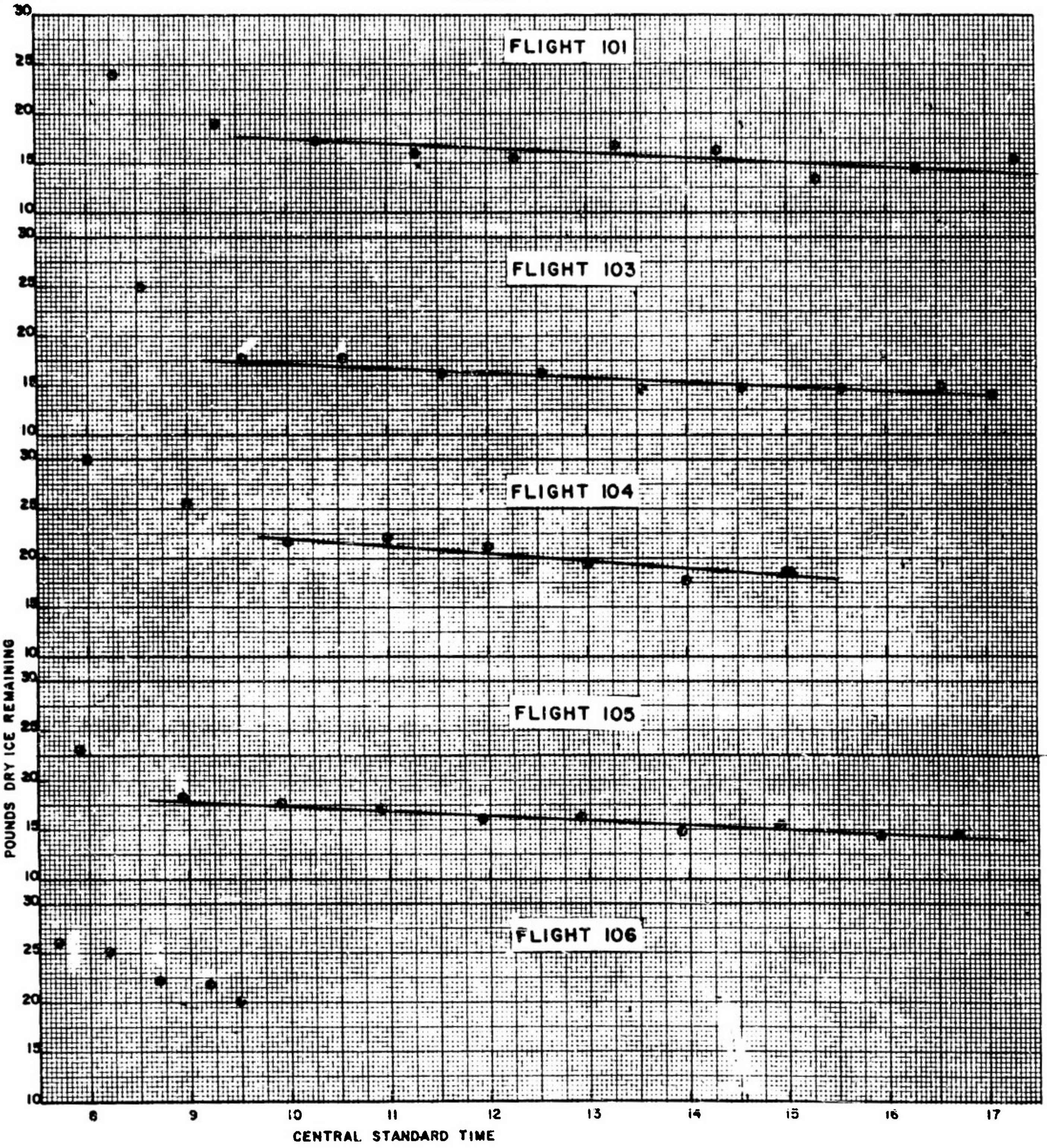


Figure X-3a. Evaporation of dry ice at high altitude. The initial rapid drop occurs at low altitude.

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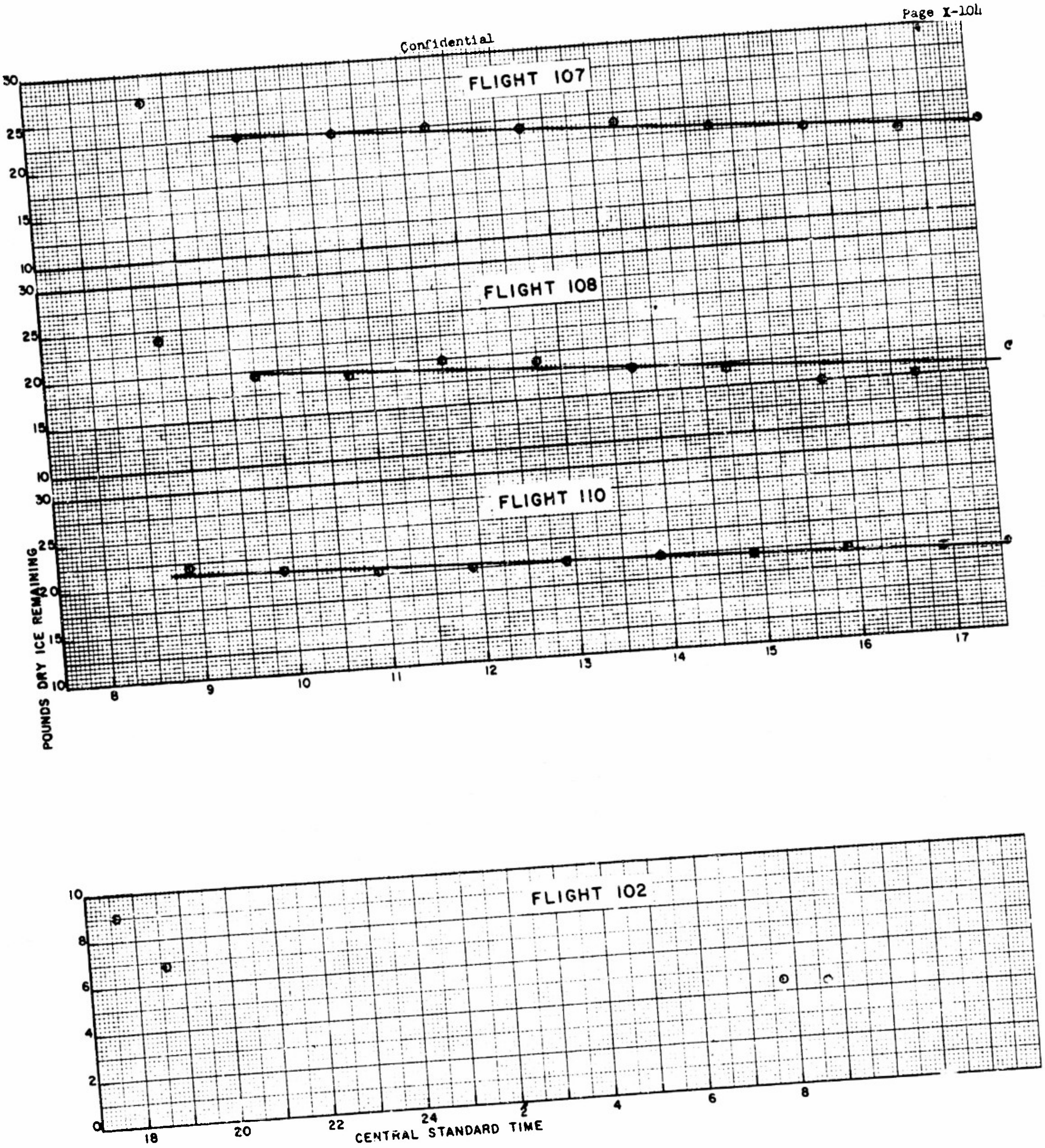


Figure X-3b. Evaporation of dry ice at high altitude.

ascending and that dur ing the constant level part at ceiling the rate of loss of weight is uniform but much lower. The data given on the curves are summarized in Table I. The daytime flights which had level sections between 60,000 and 85,000 feet give a mean rate of evaporation of 0.48 pounds per hour with the average mass of dry ice between 15 and 20 pounds. Flight 102 which was a night flight shows a considerably lower rate of evaporation but the mean mass was also considerably lower.

To derive an expression for the rate of evaporation so that the mass dependence may be known we assume that the rate of evaporation of mass is proportional to the surface area:

$$\frac{dM}{dt} = - C_o M^{2/3} \tag{1}$$

Upon integrating:

$$M^{1/3} = C_1 t + C_2$$

at

$$t = 0, \quad M^{1/3} = M_o^{1/3}, \quad C_2 = M_o^{1/3}$$

and

$$M^{1/3} - M_o^{1/3} = C_1 t \tag{2}$$

$$C_o = 3C_1$$

Using the mean rate and mass from the data

$$0.48 = 3 \cdot C_1 \cdot 17^{2/3}$$

$$C_1 = \frac{0.16}{17^{2/3}} = 0.0243$$

For this series where Av. $M_o \approx 19.7$

$$M^{1/3} - 2.70 = 0.0243t \tag{3}$$

represents the mass as a function of time for these flights, with M in pounds and t in hours.

With the value of $C = 3 \times 0.0243 = 0.0729$ we may determine the rate for dry ice in other sizes from equation (1).

Table I

DRY ICE RATES

Flight No.	Level Altitude	$W_{initial}$	$W_{ceiling}$	T	lbs/hr rate
101	60,000	24	17.5-14.1 = 3.4	7 hrs	0.48
103	80,000	25	17.1-14 = 3.1	7 hrs.	0.44
104	75,000	25.5	22-18.2 = 3.8	5 hrs	0.75
105	82,000	23	17.8-14.1 = 3.7	8 hrs	0.46
106	------	--	------------	-----	----
107	85,000	27	22.7-19.5 = 3.2	7 hrs.	0.46
108	78,000	24	19.6-16.1 = 3.5	7 hrs	0.50
110	83,000	--	21.1-18.9 = 2.2	8 hrs	0.28
			Mean rate		0.48
			Mean mass		= 17 lbs
			Mean initial mass		= 19.7 lbs
			Night flight		
102	70,000		6.8-4.5 = 2.3	13 hrs	0.18

$$\frac{dM}{dt} = - 0.073\, M^{2/3}$$

As can be seen, to meet a specific ballast rate with one block of dry ice the value of M is set. However, if many pieces may be carried, both the total M and $\frac{dM}{dt}$ may be set independently.

The evaporation rate varies with altitude, as can be seen from the high initial loss after launching. This is presumably the result of more efficient convection at low altitudes where the air density, and also temperature, are higher. The values given for the rate of loss are therefore only valid in

the range 60,000 to 90,000 feet.

The evaporation rate at night on flight 102 is 0.18 lbs/hr, somewhat lower than the value of 0.23 lbs/hr predicted by equation (1). This shows that the effect of sunlight on the dry ice is of the order of 25%. It would not be expected to be large because of the high reflectivity of the ice chunk. A large part of the visible radiation absorption may be in the net bag holding the ice cake.

The dry ice ballast has the attractive feature of a guaranteed rate of evaporation with no mechanical devices. It may be useful to compensate steady losses in lift such as gas leakage. The fact that the rate of ballasting is higher at lower altitudes is in the direction of producing stability in a balloon. system and may be worthy of further investigation.

Section XI

CHARACTERISTICS OF TIME-ALTITUDE CURVES

Recent studies on the HAB balloon flight program have lead to the conclusion that the characteristics of the time-altitude curve cannot be explained without invoking rounding of the balloon relative to the air in the daytime as it ascends to higher altitudes. The details of the altitude warming and the experiments which lead to a direct measurement of it will be reported elsewhere but this idea has a bearing on the characteristics of the time altitude curves for the Texas flights. It has been shown by other means that analysis of time-altitude curves that in the daytime, a polyethylene balloon of 2-mils thickness and with a single set of tapes will acquire something like 7% free lift by the time it has reached the stratosphere provided that it is weighed off neutral on the ground. One consequence of this altitude warming is that if a balloon is weighed off and is able to rise at all near the ground it should be able to reach ceiling provided that it does not intake air. Therefore a balloon equipped with a duct such as the Texas series should be able to reach ceiling in the daytime provided it takes off at all. In many of the Texas flights in addition to the altitude warming there was some evaporation of dry ice on the way up which leads to a small additional increase in lift on the order of 1%. This, however, is small compared to the warming with altitude which occurs for natural reasons. In order to determine quantitatively the magnitude of the warming with altitude, it is necessary to know precisely what the drag of the balloon is at a given rate, what the lapse rate of the atmosphere is and what the absolute temperature is. These data together with the rate of rise measured from the time-altitude curve can be used by means of nomographs which are included in this report to determine the free lift of the balloon at each point in its time altitude curve.

The warming with altitude produces the characteristic of the time-altitude curve, that the balloon steadily speeds up until it reaches the tropopause. At this

point the thermodynamic drag increases and remains constant throughout the stratosphere and presumably the warming with altitude ceases although at altitudes above 100 mb the warming has not been directly measured but only inferred from the time altitude curve. The normal characteristic of the time-altitude curve then is an increasing rate of rise to the stratosphere and then a slight decrease or a leveling off of the rate of rise. All of the Texas flights showed this type of behavior. The free lift which was very accurately measured in the Texas series usually amounted to something like 30 pounds free lift with air displaced on the order of 500 pounds. It is believed that the free lift could have been reduced very appreciably and apparently was very much less than this on flight 111, which took off with an initial rate of rise of about 240 feet/minute. Also because of the altitude warming one would like to avoid too high an initial free lift because in the stratosphere with the additional free lift obtained from altitude warming the rate would be excessive and the balloon might not be able to valve its gas. This apparently is what happened on our first flight, flight 101 in which the balloon acquired a high rate of rise by the time it reached ceiling, apparently tore a hole in the balloon near the bottom, descended rapidly until it took air through this hole and then floated level for a long period of time.

To show the magnitude of the altitude warming there is included in this report, a computation sheet for altitude warming on flight 111. The nomographs used to convert rate of rise to thermodynamic and aerodynamic drag, and a graph of the gain in free lift as a function of altitude on this flight is compared with that directly measured on a day flight on the HAB contract made in the summertime at Minnesota. These conditions which should be approximately equivalent to winter conditions at Pyote AFB. It can be seen that the agreement between the directly measured warming period and the warming for flight 111 inferred from the time-altitude curve is quite adequate and it should be considered that the warming with altitude is an effect

which has been experimentally demonstrated and which should be taken into account when making balloon flights.

COMPUTATION SHEET FOR ALTITUDE WARMING

Flight No. 111

Date February 1, 1953

Time of Launch 1410 CST

Location Pyote AFB, Texas

Extrapolated Weigh-off 2.1%

Air Displaced 508

Temp	Pressure Altitude	Rate of Rise	Lapse Rate	Aero Drag	Thermo Drag	Total Drag	Altitude Warming
275°	800	240	-1.95	.45%	2.3%	2.75	.65
257°	566	330	-1.95	.79	2.95	3.74	1.64
241°	400	460	-1.95	1.40	4.1	5.50	3.40
225	283	560	-1.95	1.90	5.1	7.00	4.90
218	200	680	-1.95	2.45	6.1	8.55	6.45
218	141	540	-.14	1.40	8.4	9.80	7.70
218	100	540	-.14	1.25	8.4	9.65	7.55
218	70.7	540	-.14	1.10	8.4	9.50	7.40
218	50	540	-.14	.99	8.4	9.39	7.29
218	35.4	540	-.14	.86	8.4	9.26	7.16

Figures XI-1 and XI-2 which follow are, respectively, thermodynamic and aerodynamic drag nomographs. Figure XI-3 is a graph of the gain in free lift as a function of altitude on this flight as compared with that directly measured on a day flight on the HAB contract made in the summertime in Minnesota.

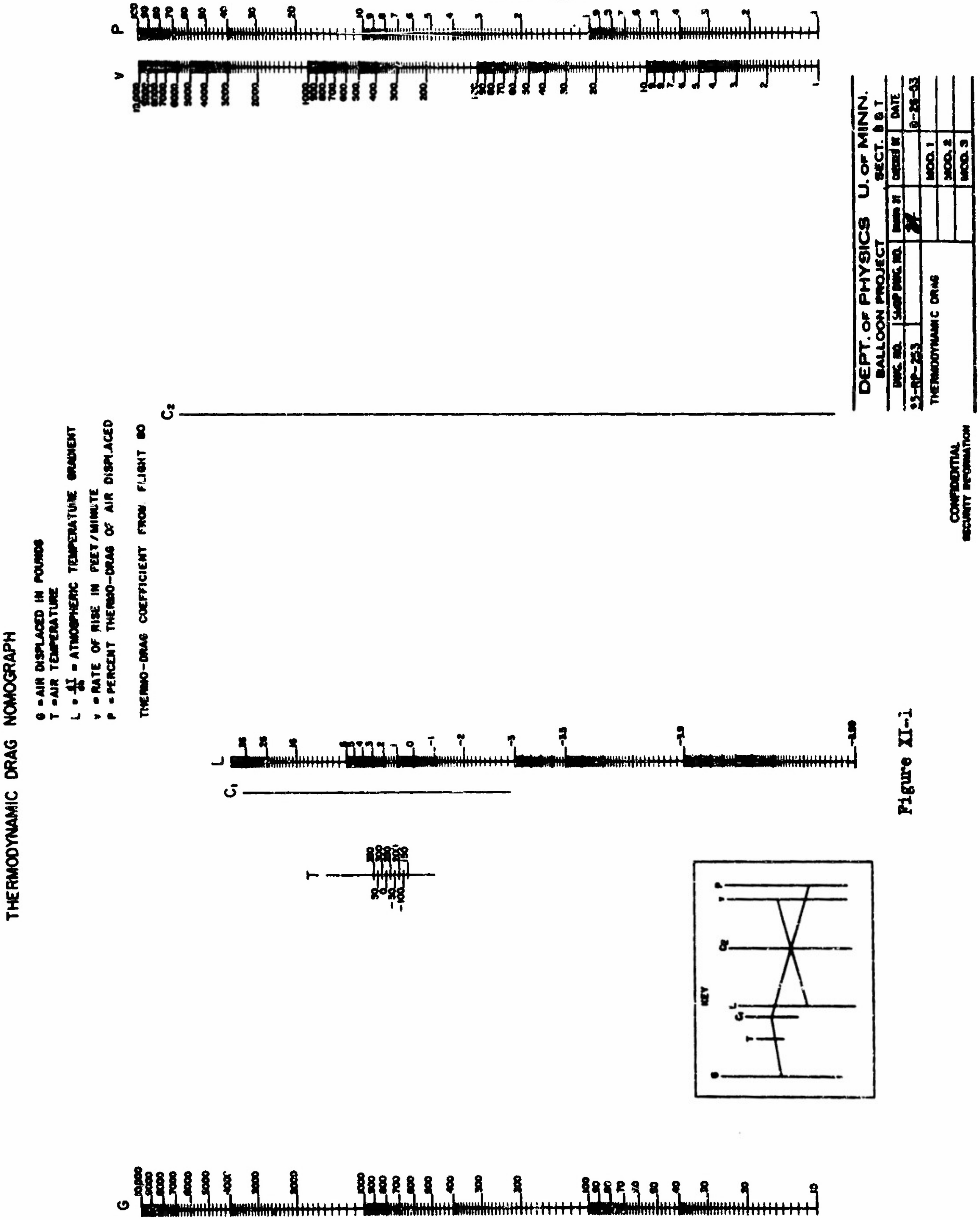

THERMODYNAMIC DRAG NOMOGRAPH
G = AIR DISPLACED IN POUNDS
T = AIR TEMPERATURE
V = RATE OF RISE IN FEET/MINUTE
P = PERCENT THERMO-DRAG OF AIR DISPLACED
THERMO-DRAG COEFFICIENT FROM FLIGHT 80
DEPT. OF PHYSICS U. OF MINN.
BALLOON PROJECT
DATE
8-26-53
THERMODYNAMIC DRAG
MOD. 1
MOD. 2
MOD. 3
CONFIDENTIAL SECURITY INFORMATION
KEY

Figure XI-1

AERODYNAMIC DRAG NOMOGRAPH

p = PRESSURE IN MILLIBARS (ASSUMES STANDARD ATMOSPHERE)

P = PERCENT AERODYNAMIC DRAG OF AIR DISPLACED

v = RATE OF RISE IN FEET/MINUTE

G = AIR DISPLACED IN POUNDS

DRAG COEFFICIENT FROM FLIGHT 80

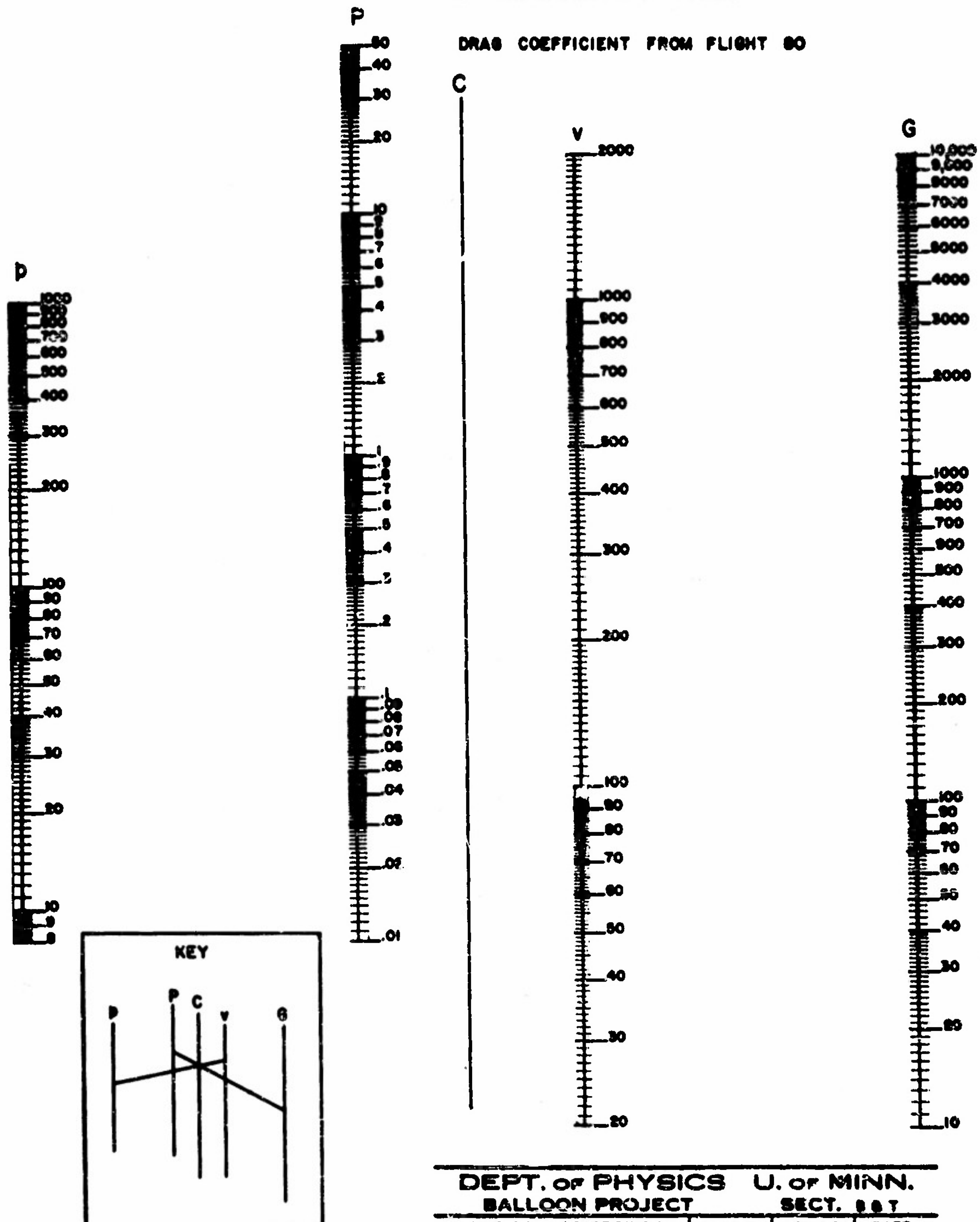
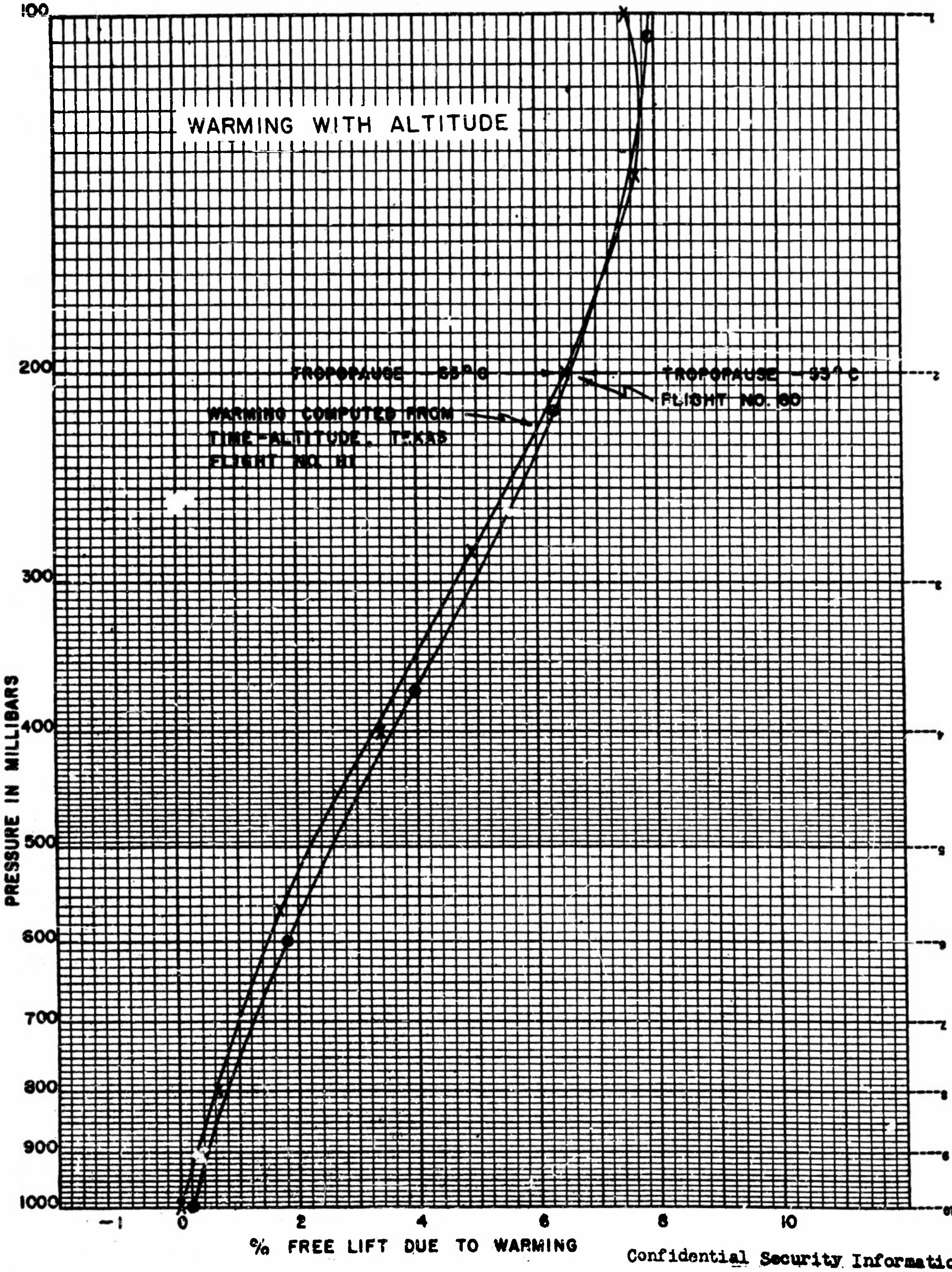


Figure XI-2

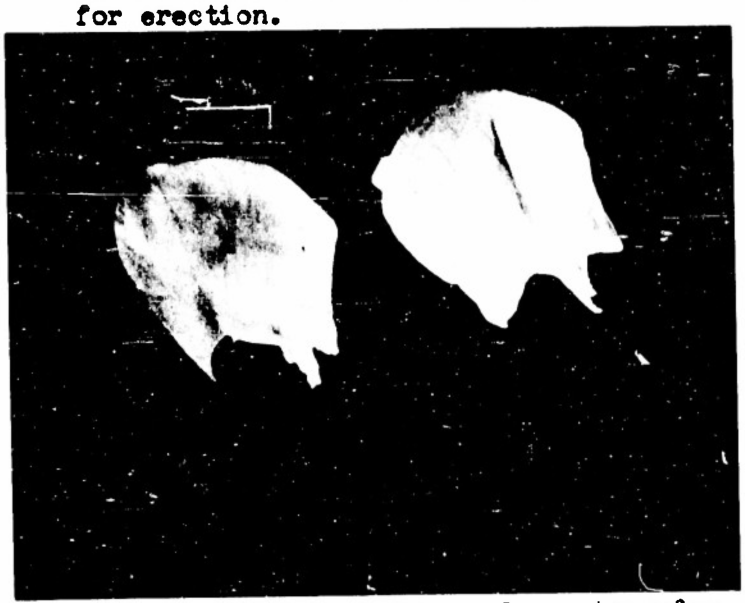
CONFIDENTIAL
SECURITY INFORMATION

DEPT. OF PHYSICS U. OF MINN. BALLOON PROJECT SECT. 8 & T				
DWG. NO.	SHOP DWG. NO.	DRAWN BY	CHECKED BY	DATE
16-RP-252		[illegible]		8-28-52
AERODYNAMIC DRAG NOMOGRAPH			MOD. 1	
			MOD. 2	
			MOD. 3	


WARMING WITH ALTITUDE
TROPOPAUSE -55° C
TROPOPAUSE -55° C
FLIGHT NO. 80
WARMING COMPUTED FROM
TIME-ALTITUDE, TEXAS
FLIGHT NO. 81
PRESSURE IN MILLIBARS
100
200
300
400
500
600
700
800
900
1000
-1
0
2
4
6
8
10
% FREE LIFT DUE TO WARMING

A. One twin erected. 2nd twin ready for erection.

B. Weigh-off



C. Launch and beginning of gas transfer.

D. Gas transfer continuing.

E. Gas transfer continuing.

F. Gas transfer nearly complete.

Figure XII-1. Sequence during twin launch. The balloons remained together as in 106 until an altitude of about 40,000 feet. At this time 107 passed over 108 and photographed it in the down camera. See Figure XII-2.

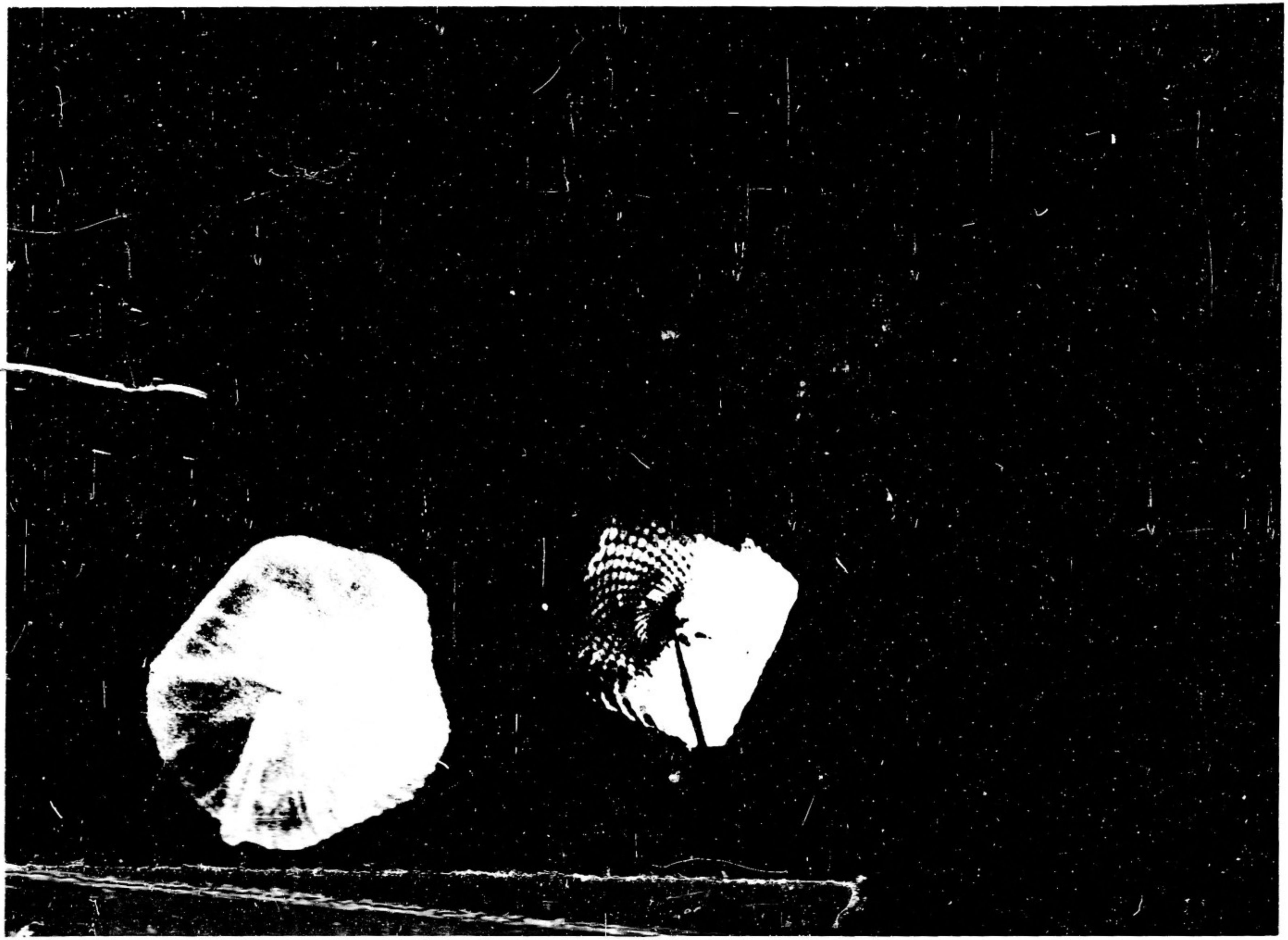


Figure XII-2. Photograph of the top of the balloon on flight 10[illegible] photographed by the down camera on flight 107. Altitude: 45,000 feet. In the immediate foreground can be seen the cake of dry ice hanging from 107 enclosed in its mesh bag. On the balloon in flight H, below, can be seen the duct appendix coming out of the top of the balloon and the various folds in the balloon which at this altitude is only partially full.